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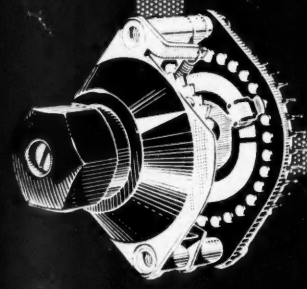
DETROIT 4

Electronic Engineering

PAINTON

By Appointment to the Professional Engineer

PAINTON WINKLER SWITCH



PAINTON

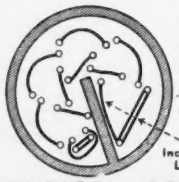
England

TWO SHILLINGS

Photo-Electric Multipliers 27M1 and 27M2

for light operated relays, film scanning, facsimile transmission, and many Research and Laboratory investigations involving low light levels.

Now available for prompt delivery



The secondary cathodes, or dynodes, of these multipliers are arranged in cylindrical formation so that they are exceptionally compact.

27M1 The 27M1 is a nine stage high vacuum photo cell with high response in the visible region. When operated at 100 volts per stage it is capable of multiplying very small currents produced under weak illumination by an average value of one million times. Under normal operating conditions the resultant output current is a linear function of the exciting illumination. The frequency response is flat up to the frequencies at which transit time of electrons within the valve becomes a limiting factor.

Because of its great sensitivity, low noise level, low dark current and freedom from distortion the 27M1 may be used for light operated relays, film scanning, facsimile transmission and in scientific research involving low light levels. In many applications its small size is an advantage. List Price: £15.

TYPICAL OPERATION

Voltage between anode and secondary cathode K10	50 volts
Voltage difference per stage	100 volts
Maximum anode dark current (with 100 volts between anode and cathode K10)	0.25μA
Luminous sensitivity (taken on the basis of a lamp colour temperature of 2700°K and a light area of 5 mm x 20 mm)	20A/lumen
Current amplification (ratio of anode sensitivity/cathode sensitivity)	10^6

27M2 The 27M2 is a nine stage high-vacuum photo-cell similar to the 27M1 except that it has wider tolerances on the anode dark current necessitating a lower anode supply voltage with a resultant reduction in the current amplification to approximately one quarter of that obtainable from the 27M1. It is capable of multiplying very small currents produced under weak illumination by an average value of 250,000 times when operated at 80 volts per stage.

The 27M2 is suitable for the same applications as the 27M1 wherever the reduced magnification is acceptable. List Price: £6.

TYPICAL OPERATION

Voltage between anode and secondary cathode K10	50 volts
Voltage difference per stage	80 volts
Maximum anode dark current (with 80 volts between anode and secondary cathode K10)	0.25μA
Luminous sensitivity (taken on the basis of a lamp colour temperature of 2700°K and a light area of 5 mm x 20 mm)	2.5A/lumen
Current amplification (ratio of anode sensitivity/cathode sensitivity)	0.25 x 10^6

Either the 27M1 or the 27M2 may be used as a plug-in replacement for the American type 931A.
A special stabilised power unit providing a highly stable H.T. supply for photo-multipliers is available.
Full details on request.

EDISWAN

MAZDA

RADIO DIVISION

THE EDISON SWAN ELECTRIC COMPANY LIMITED

Member of the A.E.I. Group of Companies

SVI

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CLASSIFIED ANNOUNCEMENTS

The charge for these advertisements at the LINE RATE (if under 1" or 12 lines) is: Three lines or under 7/6, each additional line 2/6. (The line averages seven words.) Box number 2/- extra, except in the case of advertisements in "Situations Wanted," when it is added free of charge. At the INCH RATE (if over 1" or 12 lines) the charge is 30/- per inch, single column. Prospectuses and Company's Financial Reports £14. 0s. 0d. per column. A remittance must accompany the advertisement. Replies to box numbers should be addressed to: "Electronic Engineering," 28, Essex Street, Strand, London, W.C.2. Advertisements must be received before the 14th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

JERSEY CIVIL SERVICE. The Civil Service Board of the States of Jersey invites applications for a post of Radio Technician in the States' Telecommunications Department. Candidates must have sound technical knowledge, and good practical experience in the installation and maintenance of electronic aids to navigation, wireless transmitters and receivers. City and Guilds Certificate in Telecommunications Engineering, or a pass in the Ministry of Transport and Civil Aviation's qualifying test for Radio Technicians an advantage. Salary £420 rising to £530 with prospects of establishment in the Jersey Civil Service after a qualifying period. Apply in writing to the Greffier of the States, States' Greffe, Jersey, stating date of birth and full details of education, technical training, qualifications and experience, enclosing copies of two recent testimonials and giving names and addresses of two referees. Closing date 11th September, 1954. W 2366

NATIONAL COAL BOARD invite applications for superannuable appointments as Scientific Technical Officers at their Central Research Establishment II, in Isleworth, Middlesex. The work undertaken is on basic principles and staff are required for the following fields:— (1) Problems in the control and improvement of working conditions in mines; (2) mechanical properties of coal of relevance to coal winning; (3) technical methods of coal winning; (4) design of experimental coal-getting machinery; (5) technical problems arising in coal transport, roof support, etc., (6) metallurgy, and (7) instrumentation for use in mines and laboratory in connection with the above problems. It is desirable that candidates should have at least General Certificate of Education at Advanced Level in Science subjects or Higher National Certificate in Mechanical or Electrical Engineering or Applied Physics. Previous experience in laboratory work or instrumentation would be an advantage. Appointments will be according to qualifications and experience, as Scientific Technical Officers, Grade I (scale £730 × £25 — £880). Reference No. TT/816. Grade II (Scale £485 × £20 — £705) Reference No. TT/817. Grade III (Scale £375 × £20 — £535). Reference No. TT/818. London Location Allowance of £32 10s. at the minimum rising to £62 per annum at the maximum of the above scales is payable in addition. Write, giving full particulars (in chronological order) of age, education, qualifications and experience (with dates) to National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting this paper and marking envelope with the relevant TT Reference Number quoted above. Original testimonials should Not be forwarded. Closing date 20th September, 1954. W 2376

MINISTRY OF SUPPLY requires Engineers in London to plan manufacture of precision engineering products comprising mechanical, electrical and electronic elements and assess machine tool, space and assembly requirements. Qualifications. British of British parents. Recognized engineering apprenticeship and A.M.I.C.E. or Mech. E. or E.E., or exempting qualifications. Experienced manufacture light and/or medium precision mechanical and/or electrical equipment. Familiar modern techniques and processes. Preferably experienced servo mechanisms and application of electronics in control devices. Salary. Within £650 (age 25) £1,000 Grade III (C480/54A) or £1,000-£1,320 Grade II (C481/54A). Not established but opportunities to compete for establishment may arise. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate reference number. W 2330

MINISTRY OF SUPPLY requires for Research and Development Establishments mainly in Southern England. (a) Aerodynamicists and Aeronautical Engineers (Ref. A.215/54A); (b) Electrical Engineers (Ref. D.420/54A). Posts are in Scientific Officer Grade, and for (a) require 1st or 2nd class Honours Degree or equivalent in Mathematics, Physics, or Engineering preferably with research or experimental experience of aircraft problems; for (b) 1st or 2nd class Honours Degree or equivalent in Electrical Engineering with experimental or research experience in light electrical or electronic fields. Salary according to age and experience within scale £470-£855 (London); £445-£815 (Provinces). Women somewhat less. F.S.S.U. benefits may be available. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting approp iate reference No. W 2382

MINISTRY OF TRANSPORT AND CIVIL AVIATION: Telecommunications Technical Officers, grade III. The Civil Service Commissioners invite applications from men for at least three pensionable posts. Age at least 23 and under 28 on 1st August, 1954, with extension for regular service in H.M. Forces. Candidates must possess (a) the O.N.C. in Electrical Engineering or (b) City and Guilds Intermediate Certificate in Telecommunications Engineering, plus City and Guilds Certificate Radio III, or (c) City and Guilds Certificates Telecommunications Principles III (or higher) and Radio III (or higher) or (d) produce evidence of an equivalent standard of technical education. They must also have had not less than eight years' experience in an appropriate telecommunications field, including manufacturing or maintenance or operation. London salary £480 (at age 23) to £670 (somewhat lower in provinces). Starting pay up to £580 at age 28 or over on entry. Promotion prospects. Further particulars and application forms from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S207/54. Application forms must be returned by 8th October, 1954. W 2383

NORTHERN POLYTECHNIC, Holloway, London, N.7. The Governing Body invite immediate applications for appointment as full-time Lecturer in Telecommunications Engineering for the three-year full-time course in preparation for the Full Technological Certificate of the City & Guilds of London Institute in Telecommunications Engineering. A knowledge of radar and television engineering is desirable. Salary scale—£940 × £25—£1,040 plus London Allowance. Form of application, together with full particulars, will be forwarded on receipt of a stamped, addressed foolscap envelope. R. H. Currell, A.S.A.A. Clerk. W 2361

PHYSICIST OR ELECTRICAL ENGINEER required by Ministry of Supply at Experimental Establishment in Cumberland to assist in introducing new optical and electronic instrumentation equipment to be used on ballistic trials. Normal qualification is Higher School Certificate (Science) or equivalent, but Degree or Higher National Certificate may be an advantage, some experience appropriate to above duties desirable. Salary within range Assistant Experimental Officer £276 (at age 18) — £615. Women somewhat less. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 222/54A. Closing date 10th September, 1954. W 2379

RADAR RESEARCH ESTABLISHMENT, School of Electronics, Ministry of Supply, Malvern, Worcs, requires Assistant "B" to teach mathematics to O.N.C. standard and basic principles of electronics. Degree or H.N.C. with electronics required. Salary on Burnham Technical scale £525-£820 (male), with appropriate increments for experience, and subject to Teachers' Superannuation Acts. Apply, stating qualifications and experience, to Principal, School of Electronics, Ministry of Supply, St. Andrews Road, Malvern. W 2381

THE UNIVERSITY OF MANCHESTER. Applications are invited from Graduates for two Lectureships in the Fluid Motion Laboratory. The person appointed to one of the posts will be required to work on problems of electronics and instrumentation for the measurement and observation of fluid flow, including turbulence, the propagation of shock waves and aerodynamic noise. Candidates for the other post should have special qualifications in fluid dynamics. Salary on a scale £500-£1,100 per anum: initial salary according to qualifications and experience. Membership of F.S.S.U. and children's allowance scheme. Applications should be sent not later than 11th September, 1954, to the Registrar, The University, Manchester, 13, from whom further particulars and forms of application may be obtained. W 2380.

THE WAR OFFICE requires for No. 35 base workshop, R.E.M.E., Old Dalby, Leicestershire. One Mechanical Engineering Officer (Main Grade) to control Workshop repairing radar and associated equipment. Knowledge and experience of modern electronic and allied engineering progress and process methods and technique of management essential, also ability to organize large repair programmes and production. Inclusive salary range £960-£1,240 (Provincial). Applicants must be British of British parentage and corporate members of the Institution of Electrical Engineers or have passed or be exempt from Sections A and B of their membership examination. Starting salary fixed according to age, qualifications and experience on range quoted. Annual increments subject to satisfactory service. Post temporary but long-term possibilities. Application forms from M.L.N.S., Technical and Scientific Register (K) 26 King Street, London, S.W.1, quoting D.258/54.A. W 2329

TRINITY HOUSE, London. Applications are invited for appointment to the post of Experimental Officer in the Electrical and Electronics of the Corporation of Trinity House, for work in connection with the development of electrical and electronic navigational aids. This includes the development of optical systems for fog detection apparatus, development of fog signals, audio monitoring equipment and automatic control and indication equipment. Salary scale: £720 rising to £890 per annum. The minimum qualifications required are a Science Degree, Corporate Membership of the Institute of Electrical Engineers or equivalent. All candidates must be medically fit and of British Nationality. The appointment is on an unestablished basis. Applications should be made in writing to the Secretary, Trinity House, London, E.C.3, not later than 16th September, 1954, stating age, occupation, qualifications and experience and enclosing copies of recent testimonials. W 2363

UNIVERSITY OF EDINBURGH. Department of Engineering.. Applications are invited for the post of Assistant in the Department of Engineering. The salary scale is £450 by £50 to £550 per annum. Applicants should possess an Honours Degree in Electrical Engineering and some practical experience would be desirable. Further particulars may be obtained from the undersigned, with whom applications, giving the names of two referees, should be submitted not later than 11th September, 1954. Charles H. Stewart, Secretary to the University. W 2373

SITUATIONS VACANT

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 *inclusive or a woman aged* 18-59 *inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order,* 1952.

A LABORATORY ASSISTANT is urgently required by company concerned with the manufacture of electrical equipment for aircraft to maintain general laboratory equipment, particularly that concerned with type approval testing, and to store, maintain and calibrate instruments. Position offers considerable scope and interest. While there are no particular age limits the company will be specially interested in applications from older men with this type of experience. The salary for this position will be in acordance with age and experience. Please reply, giving full details to Box No. W 2358.

A NUMBER of posts are vacant for men and women, in the research laboratories of Ericsson Telephones Limited, for Physicists,

SITUATIONS VACANT (Contd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

Physical Chemists and Electrical Engineers for work on audio frequencies, electronic switching, nucleonic equipment, semi-conductors and valves. Write giving particulars of qualifications and experience to Personnel Officer, Ericsson Telephones Limited, Beeston, Nottingham. W 2174

A SENIOR appointment will shortly be filled in the London laboratory of a firm holding contracts in guided weapon and kindred fields. Engineers who wish to be considered for this vacancy should be Graduates and should have had some experience in industrial engineering laboratories. Some production engineering experience in addition to microwave electronic and/or servo experience would be an advantage. Starting salary will range according to age and experience and will be on a generous scale and will be subject to good increases according to merit. Pension and life assurance schemes are in operation. Write, giving full details, in confidence, to Box No. W 2325.

AIRMEC LIMITED require Development Engineers and Technical Assistants in their laboratories at High Wycombe. Applicants would be required to work on the development of Commercial and Service electronic equipments, and should be capable of carrying a project through on their own initiative. Salary according to qualifications and experience. Staff Pension Scheme. Apply Personnel Officer. W 2346

AN ATTRACTIVE future offered to a Senior Electronic Engineer in young and rapidly expanding organisation. Essentials are good technical education and wide experience, together with the ability to 'get things done.' All replies answered and treated as confidential. Rivlin Instruments Ltd., 7a Maitland Park Villas, London, N.W.3. W 1117

AN OPPORTUNITY occurs in progressive manufacturing concern in London area for Engineer aged 25/35 with electrical or physicist Degree, on development and research work on high frequency telecommunication cable and associated testing equipment. Salary will be commensurate with qualifications and experience. Apply giving full particulars to Box No. W 1080.

APPLICATIONS are invited from Senior Planning Engineers, tool design draughtsmen and checker-draughtsmen. Applicants should have served a sound engineering apprenticeship and have had experience of production planning, press tool, jig and fixture design in the light mechanical and electro-mechanical engineering fields. Men between the age of 45 and 60 will be considered for the vacancies of checker-draughtsmen. These vacancies, which are caused by normal expansion of company business, offer attractive opportunities to keen and energetic men of good experience and qualifications who are capable of dealing with a varied class of work. Excellent commencing salaries will be paid to the selected candidates. Please reply, giving details of age, qualifications and experience to Box No. W 2348.

APPLICATIONS are invited from suitably qualified persons for a Senior position in the Technical Department of a lamp manufacturing organization. After an initial training period in the London area of approximately nine months, the successful applicant will be responsible for technical liaison between a factory in the Manchester area and the Technical department and development laboratories in London. The work calls for high technical proficiency combined with considerable administrative ability. Candidates should have a University Degree or equivalent and preferably some experience either in the discharge lamp or in the General Vacuum physics field. Applications should be made to The Personnel Officer, Osram-G.E.C. Lamp Works, Brook Green, Hammersmith, W.6. W 2335

ASSISTANT CHIEF ENGINEER required for design and development of radio and electronic components. Technical qualifications plus executive ability essential. Commencing salary dependent on qualifications and experience. A Pension Scheme is in operation. Apply in writing to Carr Fastener Company Limited, Stapleford, Nottingham. W 1106

A.T. & E. (BRIDGENORTH) LTD., have vacancies for Senior and Junior Electronic Engineers for (a) Production Testing and (b) Development of Production Test Gear. The work which is in a field of radio telecommunications is varied and interesting. Five-day week, good conditions. Apply in writing giving details of training and experience to Personnel Officer at Bridgenorth. W 2342

BIRMINGHAM CHARTERED PATENT AGENTS require the services of a qualified man trained in Electronics and Dynamics. Excellent prospects. Send particulars of training and career to Box No. W 2371.

BUSH RADIO LTD., have a number of vacancies in their expanding laboratories at London and Plymouth. Applicants for posts (a) and (b) should preferably hold a B.Sc., or equivalent qualification in Physics or Engineering. (a) Research and Development Engineers and Junior Development Engineers for work in new television and circuit fields. Applicants should have interests and preferably experience in:—Telecommunications, television, network analysis, feedback, pulse techniques, optics. (b) Junior Development Engineers for interesting work on Government contracts. Experience in any of the following fields would be an advantage:—Video amplifiers, feedback, pulse techniques, microwave techniques. (c) Development Engineers to initiate design and engineering layout of domestic radio receivers. Experience of design of domestic radio receivers, and familiarity with working with drawing office and production departments, are required. Good prospects, pension scheme. Interviews in London or Plymouth. Write giving full details and salary required to the Chief Engineer, Bush Radio Ltd., Power Road, Chiswick, W.4. W 2229

CHEMIST, age 25-40 required, with experience in the production of oxide coated cathodes for valves. Applicants must have had several years' experience in the valve industry. The post offers excellent opportunities for engaging in the development and pilot plant production of new types of valves. Apply Box No. W 2333.

COSTAIN-JOHN BROWN LTD., require for the instrumentation Division several engineers, aged 25-35, for interesting work on the application of process control instruments. Experience in this field is desirable, but not essential. Applications are invited for mechanical engineers and from electrical engineers with experience in electronics and/or servos. Candidates must hold a Degree or near equivalent, and should be prepared to travel. Good salary and non-contributory Pension Scheme. Apply to Personnel Manager, Costain-John Brown Ltd., 73 South Audley Street, London, W.1. W 2378

DESIGNER DRAUGHTSMAN required to join team of development engineers engaged in design of electro-mechanical and electronic instruments and equipment. Applicants should possess H.N.C. or equivalent. A knowledge of the principles of kinematics, modern electronic constructional techniques, and acquaintance with the standards of RCS 1 000 are desirable. This is an excellent opportunity for a man with energy and initiative to join a small but expanding organization. Starting salary £550-£750 per annum — depending on qualifications and experience. Applications, giving details of education and experience, should be addressed to: — Chief Development Engineer, W. H. Sanders (Electronics) Ltd., Stevenage, Herts. W 1109

DEVELOPMENT ENGINEERS required for Research and Development work on Cold-Cathode Tubes. Applicants should preferably have had experience in the Valve or Lamp industry, or on closely related work. A Science Degree, Engineering Degree, or a similar qualification would be helpful. An attractive salary is offered in accordance with experience, ability and qualifications. Please write, giving details to the Personnel Officer, Ericsson Telephones Limited, Beeston, Nottingham. (Reference LK/3.). W 2206

DRAUGHTSMAN, SENIOR, DESIGN. Good salary and prospects for first-class man. Apply in confidence stating experience, age, salary required, or telephone Wembley 1200 for appointment. Goodmans Industries Ltd., Axiom Works, Wembley. W 1110

DRAUGHTSMEN. Openings will arise in the immediate future for a number of Senior Design draughtsmen, draughtsmen and detailers who desire to progress in electronic engineering, as applied in the rapidly expanding field of VHF and UHF radio communications equipment. Pension Scheme, good salaries, and excellent conditions, at newly developed works and laboratories in the South West Middlesex area. Own staff informed. Please write giving full particulars of experience, qualifications, and when available to Box No. W 2285.

DRAUGHTSMEN. Vacancies for Designer-Draughtsman and Detail Draughtsman with experience of light mechanisms or instrument work. Modern factory in Surrey area. Five-day week, canteen, pension scheme. Box No. W. 1116.

DRAUGHTSMEN: Vacancies for senior draughtsmen with experience of Electronic and/or Electro-mechanical engineering required, preferably with experience of Ministry requirements. Excellent prospects with good commencing salaries; non-contributory Pension Scheme in operation. Applications will be treated in strict confidence and should give full chronological details of qualifications, experience and age to: John A. Smith Ltd., 24 Lichfield Street, Wolverhampton. W 201

EDISON SWAN ELECTRIC COMPANY LTD., have a vacancy for an Engineer experienced in mechanical and electronic design to take charge of their Special Products Development Laboratory. Ediswan also require Engineers with experience in the fields of electro-medical and industrial electronics design. Please write to 155 Charing Cross Road, W.C.2, stating experience and salary required. The envelope should be marked "S P. Lab." W 2352

ELECTRICAL DESIGN ENGINEER required for development work on automatic machinery. Engineering Degree or H.N.C. Sound knowledge of control circuits, small motors and electronic controls. This post offers considerable scope for progress in interesting new developments. Location Birmingham area. State salary required, age and full details of qualifications and experience to Box No. W 2336.

ELECTRICAL ENGINEER, age 25-30, with good Degree, preferably some experience in research or development laboratory, is required for work on the application of electronic techniques to industrial measurement and control. This post is permanent, pensionable and offers good prospects. Apply in writing, giving full chronological details of qualifications and experience, together with age and salary required, to Tube Investments Ltd., Department of Development & Research, Plume Street, Aston, Birmingham 6, quoting Ref. F.2. W 1078

ELECTRICAL ENGINEER, aged 25 to 30, with good Degree, preferably some experience in research or development laboratory, is required for work on the application of electronic techniques to industrial measurement and control. This post is permanent, pensionable and offers good prospects. Apply in writing, giving full chronological details of qualifications and experience, together with age and salary required. to Tube Investments Ltd., Dept. of Development and Research, Plume Street, Aston, Birmingham, 6, quoting Ref. F.2. W 1093

ELECTRICAL ENGINEER (aged 25-35) required by East London Plastic Moulders of well-known Building Trade Components. Must be highly experienced in maintaining and servicing Radio-frequency Pre-heaters as used in Plastic Industry. Give full details of experience, present employment and salary. Box No. W 2384.

ELECTRICAL ENGINEERS. Junior Technical Engineers required for development, application and pre-production of thermionic valves. Minimum desirable qualification, O.N.C., inter B.Sc., or equivalent. Write to Personnel Department, The M.O. Valve Co., Ltd., Brook Green, Hammersmith, W.6. W 1103

ELECTRONIC ENGINEER required for the Research Laboratory of The English Electric Valve Co., at Chelmsford. Applicants should have a Science Degree or equivalent qualifications, together with considerable experience in the design of circuits for experimental Television and radar equipment. Apply giving details of qualifications, experience and salary required to Central Personnel Services, The English Electric Co. Ltd., 336/7 Strand, London, W.C.2, quoting ref. 440F. W 2365

CLASSIFIED ANNOUNCEMENTS
continued on page 4

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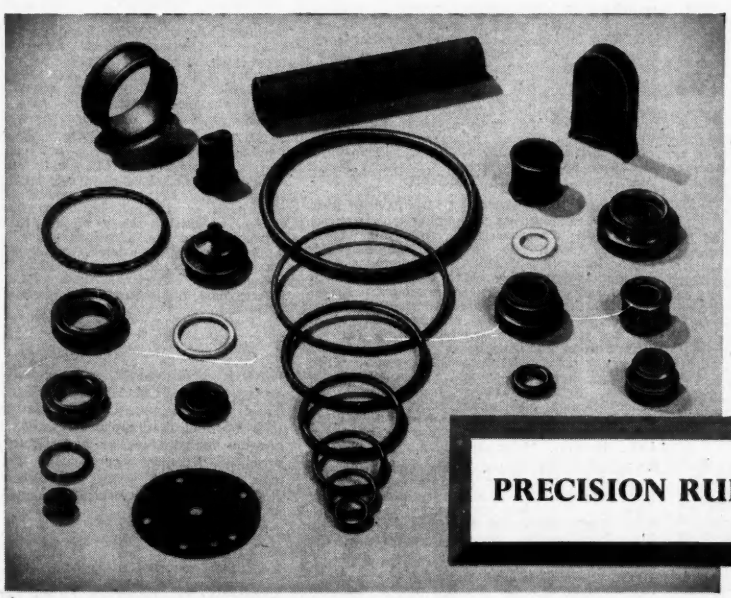

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SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

ELECTRONIC DIGITAL COMPUTORS. Electronics Engineers with an interest in mathematics are required by English Electric to work on fault diagnosis and maintenance of advanced digital computors, in the London area. Please reply to Dept. C.P.S., 336/7, Strand, W.C.2, quoting ref 1353. W 2343

ELECTRONIC DIGITAL COMPUTORS. Mathematicians with first or second class Honours Degrees are invited to apply for vacancies in the English Electric team at present working in collaboration with the National Physical Laboratories at Teddington in the design and operation of advanced and electronic computors. Please reply to Dept. C.P.S., 336/7 Strand, W.C.2, quoting ref. 1352. W 2344

ELECTRONIC ENGINEER required for interesting work mainly on Video Amplifier Development. A Degree or H.N.C. an advantage. Superannuation scheme. Apply giving full details to Personnel Department (SP) E.M.I. Ltd., Blyth Road, Hayes, Middlesex. W 2368

ELECTRONIC ENGINEER required by large telecommunication engineering works in London area for development work on Transistor Circuits. Previous experience of transistors not essential, but applicants should have a Degree or similar qualification. Some knowledge of pulse techniques an advantage. Starting salary between £600 and £1,100 per annum depending upon experience and qualifications. 38-hour, 5-day week. Pension Scheme. Box No. W 2260.

ELECTRONIC ENGINEER. Applications are invited from men preferably between 28 and 35 years of age, for an appointment with a large firm in connexion with applied nuclear energy engineering research and development. Applicants must have an Honours Degree in electrical engineering with experience in light electrical engineering and/or electronics with about six years' experience in industry, and be familiar with or have a working knowledge of electrical control gear and instrumentation. A knowledge of servo mechanisms and their application would be an advantage but is not essential. Salary would be comparable with that paid by the Civil Service, London rate, the grading depending on age and experience. Apply in the first instance to Box No. W 2251.

ELECTRONIC ENGINEER required by capacitor manufacturers (East London) for development work on test instruments and electrical research. Opportunity for young engineer with some years' experience. Write Box No. W 1104.

ELECTRONIC ENGINEER required by large company in S.W. London. Age 25-35 and preferably O.N.C. standard. Applicant must have had experience in building and servicing factory test equipment and have some knowledge of proprietary electronic equipment. The position is pensionable. Write giving details of age, experience and salary required to Box 796, c/o. J. G. King & Son, 150 Fleet Street, London, E.C.4. W 2392

ELECTRONIC ENGINEERS, aged 23 upwards, having H.N.C. or equivalent qualification, required by Electronic Instruments, Ltd., Richmond, Surrey. Written applications only in first instance. W 199

ELECTRONIC TECHNICAL ASSISTANT required for the construction of specialized apparatus and instruments for vibration laboratory. Must be capable of working from circuit diagrams and should have had some Service or Civilian experience in similar fields. Please write stating age and giving full details of previous experience to the Personnel Officer, The De Havilland Engine Co., Ltd., Stag Lane, Edgware, Middlesex. W 2328

ELECTRONIC TEST EQUIPMENT ENGINEERS required by large reputable electronic and radar manufacturing company to operate a new factory in the South. Vacancies exist for: A. Experienced Circuit Checker and routiner Designers. B. Radar production test gear Designers. C. Microwave component test gear Designers. Applicants must have had previous experience in a similar position. Superannuation and housing facilities will be available. Salary commensurate with ability. State full experience and age to Box No. W 2326.

ELECTRONICS ENGINEER required to handle design and development of industrial and special purpose electronics equipment. Qualifications and experience must be up to A.M.I.E.E. standard. Permanent, progressive position with non-contributory pension plan in operation. Salary according to age and experience. Apply in writing to Personnel Department, Kodak, Wealdstone, Middlesex. W 2364

ELECTRONICS ENGINEER required with experience in Microwave Design and development. Salary according to qualifications. Write, Microwave Instruments Limited, West Chirton Industrial Estate, North Shields, Northumberland. W 2398

ELECTRONICS SENIOR ENGINEER required for design and development of electronic and telecommunication equipment. Applicants must be suitably qualified, with previous experience in this field. Good salary. Full details to Personnel Manager, Vidor-Burndept Limited, Erith, Kent. W 2393

ENGINEER required for Technical staff of Scottish Council (Development and Industry). Work includes assistance to inquirers (such as firms, Local Authorities), attraction of plant investment to Scotland; development of new industrial projects. Degree or equivalent required: industrial experience desirable. Age preferably under 40. Salary in the range £900 to £1,200; superannuation scheme. Apply with particulars of qualifications and experience to the Secretary, Scottish Council (Development and Industry), 1 Castle Street, Edinburgh, 2, marking envelope "Technical." W 2338

ENGINEERS AND ASSISTANTS required for responsible trials work at Feltham, Middlesex, and West Wales, on Guided Weapons. Good general scientific education up to Degree standard desirable. Enthusiasm for this interesting but often arduous work essential. A fair amount of travel may be involved. Preference given to candidates who have previously held responsibility for test and repair of electro-mechanical and electronic devices. Apply with full details, including salary, quoting No. 1492 to Personnel Manager, Sperry Gyroscope Co. Ltd., Great West Road, Brentford, Middlesex. W 2377

ERICSSON TELEPHONES LTD., have in their Research Laboratories a number of vacancies for circuit designers and equipment engineers to work on nucleonic instruments, and interesting new developments in electronic computing and switching; both senior and junior posts are available. Applicants should have a degree or equivalent plus several years' experience of appropriate work for the senior posts; correspondingly reduced qualifications and experience will be accepted for junior posts. Salaries will be in accordance with age, qualifications and experience. Applications, giving details of age, academic or other training and qualifications, experience, and starting salary required, should be sent to the Personnel Officer, Ericsson Telephones Ltd., Beeston, Nottingham. W 197

EXPERIENCED Radio Testers and Inspectors required for production of communication and radio apparatus. Also Instrument makers, wirer and assemblers for Factory Test apparatus. Apply Personnel Manager, E. K. Cole Ltd., Ekco Works, Malmesbury, Wilts. W 146

FERGUSON RADIO CORPORATION LTD., have vacancies for: Senior Engineers with initiative and sound technical background for work on a wide range of projects in the field of Electronics including Television, Radio Communications and Test Equipment. Permanent posts for men able to carry responsibility in rapidly expanding departments offering exceptional promotion and long-term prospects. Junior Engineers of ability for work on Development projects offering a wide experience in the fields of Television, Radio Communications and Test Equipment with excellent prospects for advancement. Vacancies exist in laboratories situated at both Enfield and Spennymoor, Co. Durham. These laboratories are well equipped and working conditions excellent. Successful applicants eligible for Company's Pension and Life Assurance Scheme. Applications specifying the post for which application is made and giving full particulars as to age, qualifications and experience, etc. to: Personnel Manager, Ferguson Radio Corporation Ltd., Great Cambridge Road, Enfield. W 2353

FERRANTI LTD., (Computor Department) Moston, Manchester, have the following vacancies. (1) Senior Engineers for Research and Development work on large-scale electronic computing equipment. Previous research or development experience in electronics or with electromechanical devices is essential and candidates should preferably possess a first- or good second-class Honours degree in Electronic Engineering. Reference DCSE. (2) Engineers of approximately graduate status to be trained for maintenance of computing equipment. Experience in the servicing of large electronic equipments such as radar systems would be an advantage. On completion of training these engineers would have a considerable degree of responsibility away from the factory and there might be opportunity for overseas work. Reference DCME. Permanent staff appointments with pension benefits. Application forms from Mr. T. J. Lunt, Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Please quote appropriate reference. W 2375

FIRM of consulting Geophysicists have openings for young electronic engineers, preferably single, on oil prospecting parties overseas. Commencing salary £50 per month plus allowances depending upon area of operations. Free accommodation and messing provided when serving abroad. Qualifications Higher National or C. & G. Certificates in Electrical Engineering or Telecommunications. Pension fund. Apply giving particulars of experience to Box No. W 1119.

GRADUATES with Honours Degrees in Physics or in Electrical Engineering are required by the British Thomson-Houston Company, Rugby, for research in the field of magnetron development; some knowledge radar is desirable. Applicants should write to the Director of Research giving their age, qualifications, and college, quoting reference DR. W 2362.

GUIDED WEAPONS. Vickers-Armstrong Limited, Weybridge, has vacancies for suitably qualified Senior and Junior Technicians, Engineers, Craftsmen in the Electronics, Electrical and Mechanical sections of the Guided Missiles field of research and development. Applications should be made to the Employment Manager, Vickers-Armstrong Limited, Weybridge Works, Weybridge, Surrey. W 2367

JUNIOR DRAUGHTSMAN required to join team of engineers engaged in the design and development of Microwave and Radar equipment. This is a good opportunity for an energetic and keen young man to obtain advancement in a small but expanding organization. Starting salary £7 to £10 per week depending on qualifications and experience Applications, giving details of education and experience, should be addressed to: Chief Development Engineer, W. H. Sanders (Electronics) Ltd., Stevenage, Herts. W 1108

JUNIOR ENGINEERS required with qualifications up to H.N.C. standard for work in connexion with precision electrical apparatus. It is essential that applicants should have had previous industrial design and development experience. Excellent opportunities for advancement. Usual staff privileges available. London area. Please reply, giving full details to Box No. W 2350.

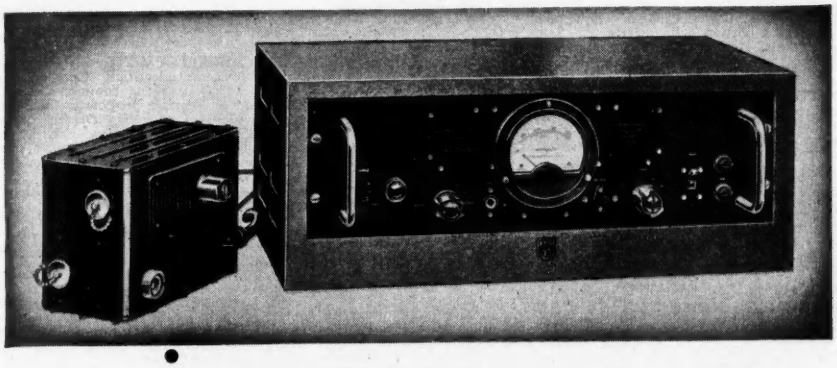
KELVIN AND HUGHES LTD., Barkingside, Essex, have vacancies for Research Engineers for experimental work relating to underwater sound apparatus. Applicants should be of Degree standard and should have a sound

CLASSIFIED ANNOUNCEMENTS
continued on page 6

vastly superior

STABILITY and SIMPLICITY

EKCO Type 1079c VIBRATING REED ELECTROMETER



Although designed for Ionization Current measurements, this instrument solves many problems involving the measurement of very minute direct currents and voltages, including those associated with pH measurements. It replaces all forms of valve electrometers, having outstandingly good zero stability. In place of the usual D.C. amplifier, the applied D.C. is converted into A.C. by means of a vibrating condenser, then passed to a high-stability negative feedback amplifier whose output is rectified and measured. Direct indication of the applied voltage is given on a built-in meter; provision is also made for operating an external recorder. The complete instrument comprises two units, the Electrometer Head and the Indicator Unit, interconnected by cables which can be up to 200 ft. in length.

This instrument was designed in association with the British Atomic Energy Research Establishment.

Specification

4 Ranges: *0-30, 0-100, 0-300, 0-1000 millivolts.*

Sensitivity: *At maximum sensitivity the instrument gives F.S.D. for 0.03 micro-micro-amps.*

Accuracy: *Of the order of + 5%*

Stability: *Day to day, + 1 millivolt*

Input: *3 switched resistors, 100 megohms, 10,000 megohms, 1 million megohms.*

Output: *Unit will operate a 1 mA or 100mV recorder.*

External supplies: *6.3V 0.3A and 200v 5mA available for operating external equipment. Compartment provided for 90V battery for polarizing ion chambers.*

Please write for the complete catalogue of Ekco electronic and nucleonic equipment

EKCO *electronics*

EKCO ELECTRONICS LTD · SOUTHEND-ON-SEA · ESSEX

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

knowledge of communications, in particular electronics. Applications stating salary required should be addressed to the Personnel Manager. W 2292

KELVIN AND HUGHES LTD., Barkingside, Essex, have vacancies for Technical Assistants for development of electro-mechanical and electronic instruments (Marine). Work involves initial experiments, sea-going trials, pre-production models and factory liaison. Occasional visits overseas are arranged. Qualifications:—Practical: five years workshop or drawing office experience. Academic: City and Guilds Telecommunications Final Group Certificate, or equivalent. Applications, stating salary required should be addressed to the Personnel Manager. W 2293

KENT EDUCATION COMMITTEE. Medway College of Technology required September, or as soon after as possible. Assistant Lecturer (Grade B) in Telecommunications and Radio Engineering. Applicants should be graduates or similarly qualified to teach to the standard of the City and Guilds Telecommunication Engineering and the Radio and Television Servicing Certificates, and must have had sound industrial experience. Previous teaching experience is desirable but not essential. Salary in accordance with Burnham Technical Scales 1954 which have not yet been published. The existing Grade B Scale is £490 × £25 basic with additions for approved qualifications, training and experience. Opportunity for extra paid evening teaching. Forms of application from the Registrar to be returned to him as soon as possible, at Medway College of Technology, Horsted, Chatham. W 2372

LABORATORY ASSISTANT required for interesting and varied work, involving acoustic and vibration measurements, use of strain gauges, pyrometry, and the development, application and servicing of electronic equipment as applied to the testing of steam and gas turbines, gears, alternators, etc. Practical experience of electronic equipment, and completion of National Service, if age under 26, essential. H.N.C. and engineering experience an advantage. Staff Pension Scheme. Apply, stating experience, age and salary required to the Secretary, W. H. Allen Sons & Co., Ltd., Queens Engineering Works, Bradford. W 2351

LOUDSPEAKER DEVELOPMENT ENGINEER to work in extremely well equipped laboratory. Good prospects for man with creative ability. State experience, age, salary required, or telephone 1200 for appointment. Replies treated confidentially. Goodmans Industries Ltd., Axiom Works, Wembley. W 1111

McMICHAEL RADIO LTD., require Senior and Junior Engineers in their equipment division laboratory at Slough. Training and experience in the field of applied electronics (including communications) and experience of working with Government Departments are the chief qualifications required. Write stating age and full details of training, qualifications and experience to the Chief Engineer, Equipment Division, McMichael Radio Ltd., Slough, Bucks. W 157

MECHANICAL DEVELOPMENT ENGINEER required for work on varied and interesting projects. Applicants should be of Degree or H.N.C. standard with experience of camera, light servo-mechanisms or electromechanics design. Good prospects with progressive firm in Surrey area. Five-day week, canteen, pension scheme. Apply with full details of previous experience to Box No. W 1127.

MICROPHONE DEVELOPMENT ENGINEER to work in extremely well equipped laboratory. Salary according to experience. Good prospects for man with creative ability. Write in confidence stating age, salary required, experience, or telephone Wembley 1200 for appointment. Goodmans Industries, Ltd., Axiom Works, Wembley. W 1112

MULLARD RESEARCH LABORATORIES require Graduate Engineers or Physicists with circuit experience, to carry out research into the application of transistors and semiconductor devices. Initially the work will be concerned with high frequency junction transistors and power junction transistors. The fields of application will include Computors, Television and Communication Systems and experience in one of these fields will be an advantage. The work calls for high degree of individual responsibility and there is a great scope for initiative and inventiveness. Salaries are based on qualifications, experience and age, and are in keeping with present-day levels. General prospects within the organization are excellent. Apply to Personnel Manager, Mullard Research Laboratories, Cross Oak Lane, Salfords, near Redhill, Surrey, quoting reference E.R.L. W 2303

OLD ESTABLISHED BRITISH COMPANY in Far East requires the services of a Technical Sales Assistant. Candidates should preferably be between the ages of 23-27, of good education and have a general knowledge of some of the following: (a) Broadcast and Telecommunications Equipment; (b) Television; (c) Cinema Equipment; (d) Light Electrical Engineering. Sales experience an advantage. Write in confidence to Box JN/159 c/o 95 Bishopsgate, E.C.2. W 2286

PYE LIMITED require experienced Development Engineers for radio receiver development in Cambridge. Salaries in the range of £400 to £800 according to qualifications. Apply Personnel Department, Pye Ltd., St. Andrew's Road, Cambridge. W 2187

RESEARCH AND DESIGN ENGINEERS required for very interesting new projects. Knowledge of one or more of the following subjects preferable: (1) Analogue Computors, (2) Servos and Control Systems including feedback amplifiers (3) Instrument type Electrical Machines, (4) Mechanical Instruments, (5) Industrial Electrical Machines of medium and large output. A University Degree or equivalent is a necessary qualification. For some senior appointments, practical experience of design development or research in some of the above subjects is an essential additional qualification. Please send full details of education, experience and salary required to : The Secretary, Laurence, Scott & Electromotors Ltd., Gothic Works, Norwich. W 1123

RESEARCH & DEVELOPMENT ENGINEERS are required by British Telecommunications Research Ltd., a company associated with the Automatic Telephone & Electric Co., Ltd., and British Insulated Callender's Cables Ltd., for work on long term development projects in the following fields:—(a) Wide-band line communication systems; (b) Microwave radio systems; (c) Point-to-point television transmission systems; (d) Measuring and testing equipment for the above. Attractive posts are offered to qualified engineers with experience in any of the above fields, and further vacancies exist for junior engineers and technical assistants. The Company operates a superannuation scheme, and offers attractive working conditions with generous holiday and leave arrangements and good social and recreational facilities. All applications will be dealt with in confidence and should be addressed to the Executive Director, British Telecommunications Research Ltd., Taplow Court, Taplow, Bucks. W 2360

SALES ENGINEER required for London office of the equipment division of Mullard Ltd. Candidates should have previous experience preferably of H.F. and V.H.F. Communication equipment. Permanent and pensionable appointment. Write giving age, and full details of education, training, previous experience and salary required to the Personnel Officer, Mullard Ltd., Century House, Shaftesbury Avenue, London, W.C.2. W 2337

SENIOR AND JUNIOR DESIGN DRAUGHTSMEN required for interesting work in connexion with electronic equipment, commercial radio and television and/or light electro-mechanical engineering. London area. The positions vacant offer ample scope and opportunity for future advancement to men of good ability. A high salary will be paid to the selected candidates. All recognized staff privileges available. Please reply, giving full details of experience to Box No. W 2349.

SENIOR AND JUNIOR ENGINEERS required for research and development work on magnetic amplifiers, transistors and electronics, with particular reference to aircraft and guided weapon applications. Full particulars of qualifications, experience and salary required to Box No. W 1114.

SENIOR DEVELOPMENT ENGINEERS. Vacancies exist in the outer London area for Senior Development Engineers to work on the study, development and engineering of phototype electronic equipment involving considerable mechanical appliances on digital computing, measuring equipment, atomic control and G.W. operational equipment. These posts are pensionable and offer considerable future prospects. Applications should be sent in confidence to Box No. W 2324.

SENIOR DEVELOPMENT ENGINEERS required by large electronic Company in N. London area, for radar communications, television and instruments projects in their development division. Engineering Degree, or equivalent professional qualifications. Experience in developing to Government and other specifications and directing work of development engineers. Salary scale up to £1,500 p.a. according to experience. Accommodation available. Write Box No. W 2406.

SENIOR ENGINEER INSPECTOR with Higher National Certificate, A.M.I.E.E., A.M.I. Mech.E., or equivalent, required by The English Electric Co. Ltd., Luton. Knowledge of servo systems, hydraulics, electronics, gyroscopes and airframes required. Should preferably have had experience as Chief Inspector or Deputy Chief Inspector with A.I.D. approval. Apply to Department C.P.S., 336/7 Strand, W.C.2, quoting Ref. 1355. W 2385

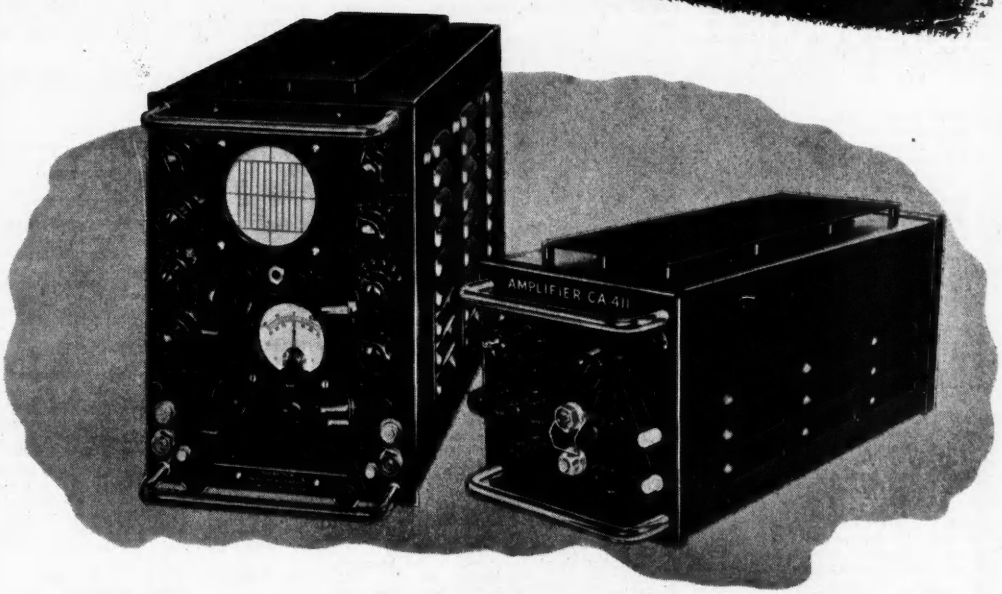
SENIOR PHYSICISTS AND ENGINEERS are invited to write to the Research Director of Decca Radar Limited, regarding the opportunities which exist in this company owing to the continual expansion of its activities in the field of navigational aids and communication. Senior posts available are on a very substantial salary scale and there are excellent prospects of higher appointment for men of proven ability. British nationality is essential. A Pension Scheme is in operation. Letters giving full personal data should be addressed to the Research Director, Decca Radar Limited, 2 Tolworth Rise, Surbiton, quoting reference RLA/47. W 2327

SERVOMECHANISMS ENGINEER required by Gloucestershire firm for theoretical work on aircraft automatic control systems. Good Honours Degree and sound experience necessary. Apply Box No. W 2374,

SHORT BROTHERS AND HARLAND LIMITED have vacancies in their Research Department for the following additional staff to work on guided Missiles and other interesting military and commercial projects. Mechanical Section: Senior Engineers, Engineers and Technical Assistants to develop hydraulic and pneumatic servos, precision mechanical devices, etc. Electronics Section: Senior Engineers, Engineers and Technical Assistants to work on computing, navigational and servo systems. Electro-mechanical Section: Engineers and Technical Assistants to develop small electro-magnetic devices, navigational instruments, etc. Qualifications: Senior Engineers. Honours Degree plus at least 5 years' good engineering development experience. Engineers: University Degree or equivalent with several years' experience of development work. Technical Assistants: H.N.C. or equivalent, with good practical experience in appropriate field. These are permanent positions in an expanding organization. Good salaries and prospects for men with initiative: Pension scheme; assistance with housing. Send full particulars of age, qualifications and experience, with salary required to Short Brothers and Harland Limited, Castlereagh Factory, Belfast, quoting Ref. No. E9. W 2345

CLASSIFIED ANNOUNCEMENTS
continued on page 8

performance+ real reliability+ attractive prices and deliveries



OSCILLOSCOPE D 300 and AMPLIFIER CA 411

COMBINED SPECIFICATION

Bandwidth: 2 c/s–5 Mc/s (6 db) gain × 90.
Input Impedance : 1 megohm shunted by 30 pf.

SPECIFICATION for AMPLIFIER CA 411

Bandwidth : 2 c/s–5 Mc/s (3 db) on gains of 3, 10 and 30.
Input Impedance : 1 megohm shunted by 30 pf.
Mains Input : 200–250 volts 50 c/s. Consumption 100 V.A.
Dimensions : 7″ × 7″ × 14″.
Weight : 20 lb. **U.K. Price : £55.**

Tailored for use with the oscilloscope and built to the same standard, this new amplifier enables 1 volt signals to be displayed from 2 c/s–5 Mc/s, thus extending the use of the oscilloscope to television and video applications. In addition it has a high gain position giving a combined sensitivity of 30 millivolts for measurement of hum levels. It can also be used as a straight H.F. amplifier for increasing the output from oscillators, H.F. signal generators, bridges, etc., and may also be used to increase trigger sensitivity.

For further details write to : **Dept. E.2,**

SOLARTRON ELECTRONIC GROUP LTD.
Solartron Works, Queen's Road, Thames Ditton, Surrey.
Telephone : Emberbrook 5611. Cables : Solartron, Thames Ditton.

COSTS UNDER OUR GUARANTEE HAVE NEVER EXCEEDED 0.2% OF SALES.

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

SHORT BROTHERS & HARLAND LTD., Belfast require a Laboratory Superintendent for their Research Department. The position involves responsibility for providing equipment supplies and services in the Laboratories; also control of Laboratory personnel. Candidates should possess organising ability, and be familiar with the running of a Laboratory or Workshop. Experience in light electrical equipment or precision instruments essential. Considerable tenacity and drive necessary to co-ordinate and sustain action with external official bodies. This appointment is suitable for a retired officer of one of the Technical Branches of the Services. Assistance with housing, and with removal expenses. Send full details of age, qualifications and experience, quoting Ref. 613/ST.App. to Staff Appointments Officer, Short Bros. and Harland Ltd., P.O. Box No. 241, Belfast. W 2386

SIMMS MOTOR UNITS LTD., require a laboratory assistant for research and development of electronic and electro-mechanical mechanisms associated with the commercial vehicle industry. H.N.C. or equivalent standard. Apply by letter stating age, qualifications and experience to Personnel Manager, Simms Motor Units Ltd., Oak Lane, Finchley, N.2. W 1120

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT Limited have vacancies for qualified Electronic Engineers for Flight Trials work on guided missiles. Experience on electronic experimental work or Service experience on radio or radar is essential. Age limits 27-38 years. Applications, giving particulars of qualifications and experience, should be addressed to The Chief Engineer, Armaments Division, Sir W. G. Armstrong Whitworth Aircraft Ltd., Baginton, Coventry. W 2321

TECHNICAL ASSISTANT, Inter.B.Sc., or Higher National Certificate together with some years' experience in electronic circuitry, required at Research and Development Dept., near Epsom. Please apply: Staff Manager, The Distillers Co. Ltd., 21 St. James's Square, S.W.1. Quote Ref.: Res. 654. W 2379

TECHNICAL OFFICERS (COMMUNICATIONS) required for Middle East service with large oil company. Applications are invited for the following posts from those with at least six years' experience with British Post Office or comparable organization. (1) Lines. Practical experience essential in installation and maintenance of multi-channel carrier equipment. Additional knowledge of voice frequency telegraph equipment and/or small automatic telephone exchanges desirable. Knowledge of Radio Communications an advantage. Qualifications must include C. & G. Telecommunications (Principles) 11 and line transmission 1 or telegraphy 1 (2). Radio. Practical experience in charge of installation and maintenance of radio equipment including M.F. and H.F. transmitters up to 1 KW and low power V.H.F. systems. Knowledge of line, telegraph and telephone systems an advantage. Technically qualified at least to third year standard City and Guilds Telecommunications. Age limit for these vacancies is 35 and bachelors are preferred owing to shortage of married accommodation. Pensionable emoluments from £900 (incremental) plus substantial local allowances and paid home leave with passages. Write please, referring to either (1) or (2) above and quoting No. 465 to Box No. 7856, c/o Charles Barker & Sons Ltd., 31 Budge Row, London, E.C.4. W 2355

TECHNICAL SALES REPRESENTATIVE. A leading firm of instrument manufacturers requires a Young Engineer to act as a Technical Sales Representative. Applicants should be about 25 years of age, of good address, and should hold a National Certificate in Elect. Eng., or similar qualification. A knowledge of instrumentation is desirable. The successful applicant will receive initial training at the company's works in London. Commencing salary dependent on experience. Write Box No. W 2331.

TECHNICAL WRITER with command of good English to create publicity material and deal with technical correspondence. Apply in confidence, stating age, salary required, experience, or telephone Wembley 1200 for appointment. Goodmans Industries Ltd., Axiom Works, Wembley. W 1113

TECHNOGRAPH PRINTED CIRCUITS LTD., 32 Shaftesbury Avenue, London, require the services of an experienced representative well introduced to the Electronic and Electrical Industries. Good salary to suitable man. Write to Sales Director as above. W 1115

THE ELECTRONICS DEPARTMENT of a large manufacturing Company requires enthusiastic and experienced senior and junior electronic and electro-mechanical engineers for new developments in internal and commercial instrumentation work. The Company is situated in pleasant countryside on the outskirts of Wolverhampton. A superannuation scheme is in operation. Initial salaries will be commensurate with ability and there are good opportunities for advancement. Box No. W 1122.

THE ENGLISH ELECTRIC CO., LTD., Chelmsford, have vacancies for young Engineers to work on radio valve design and development. Applicants should be of Degree standard. Whilst experience of this type of work is desirable, it is not essential and otherwise suitable candidates will be considered. Write giving full details quoting Ref. 497F to Central Personnel Services, The English Electric Co., Ltd., 336/7 Strand, London, W.C.2. W 2356

THE GENERAL ELECTRIC CO., LTD., Brown's Lane, Coventry, require Senior and Junior Electronic Development Engineers for work on Guided Weapons and like projects, particularly in the field of Microwave and Pulse Applications. Mechanical Development Engineers, Designer Draughtsmen and Draughtsmen, preferably with experience of Radar type equipments, also required for the above projects. Salary according to age, qualifications and experience. Apply by letter, stating age and experience to the Personnel Manager (Ref. R.G.). W 169

THE R.Y. PICKERING GROUP OF COMPANIES, which is considerably expanding its Electronic Division, has a vacancy for a Chief Electronic Engineer and invites applications for this position. Applicants must possess a University Degree and have experience in research, development and production of electronic and similar apparatus and some administrative experience is desirable. Salary in accordance with qualifications, experience and age will be upwards of £2,000 per annum and certain amenities may be provided. The post offers considerable scope, will be progressive and will suit an engineer rather than a physicist. Further information will be given on request and applications in writing in the first instance should be made to the Managing Director, R. Y. Pickering & Co. Ltd., Netherton Works, Wishaw, Lanarkshire, and will be treated in strict confidence. W 1121

TRANSFORMER DESIGNER required for development projects involving audio-frequency power transformers, pulse transfomers, oil-filled units, etc. Apply stating age, qualifications and experience to the Personnel Manager (Ref. R.G.), The General Electric Co., Ltd., Brown's Lane, Allesley, Coventry. W 192

TRANSISTORS. British Tabulating Machine Co., Letchworth, Herts, has a vacancy for an Honours Graduate engineer or physicist for research and development work on the use of transistors in pulse and switching circuits. Applicants should have experience of transistor circuit techniques and preferably pulse circuits as used in digital computing, radar, etc. Salary will be based on qualifications, age and experience. Applications should be sent to the Personnel Officer, marked Ref. EE.248, and stating age, experience and training. W 1079

UNICAM INSTRUMENTS invite applications from physicists for electronic research and development in the field of spectrophotometry. Write in the first instance to the Director of Research, Unican Instruments Ltd., Arbury Works, Cambridge. W 200

VACANCY FOR JUNIOR TECHNICAL ENGINEER, Electronics Section. Qualifications: preferably Honours Degree, specializing in Electronic Science; should have had reasonable practical experience in application to Engineering problems and be able to devise and adapt equipment for specialized instrumentation purposes to high speed mechanical problems associated with aero-engine application. Applications giving details of age, experience and qualifications should be addressed to The Personnel Manager, Bristol Aeroplane Company Limited, Engine Division, Filton, Bristol. W 2332

VACANCIES exist for Engineers on the design and development of small electro-mechanical and electronic components. Applicants should have H.N.C. or equivalent and experience in this field with the initiative and ability to progress designs up to production standard. The vacancies have excellent opportunities for men of good ability, an excellent salary will be paid to the selected applicants. Please reply, giving full details of qualifications and experience to Box No. W 2357.

YOUNG SALES ENGINEER required for component sales division. Age limits 24/30. Qualifications equivalent to H.N.C. (Electrical). Selling or commercial experience desirable but not essential. Applicants must be willing to travel. Excellent prospects. Write Personnel Manager, Telephone Manufacturing Co., Ltd., Sevenoaks Way, St. Mary Cray, Kent. W 2354

Further "Situations Vacant" advertisements appear in display form on pages 99, 115, 119, 121.

SITUATIONS WANTED

DESIGNER/DEVELOPMENT ENGINEER. 18 years experience electro-medical, electrical and electronic equipment, scientific instruments. Ambitious to gain wider recognition for designs which are both technically sound and aesthetically good. Seeks employer who can offer improved facilities, salary and prospects. Box No. W 1124.

HONOURS GRADUATE. 30, Apprenticeship, some experience U.H.F., industrial Electronics, teaching seeks post with opportunities in the London area. Box No. W 1118.

LECTURER, telecommunications, broadcasting, television. A.M.I.E.E. Long experience lecturing, design, etc., requires evening lecture work, London or Surrey. Box No.W 1105.

YOUNG MAN, 25, married, with H.N.C. in electrical engineering seeks an interesting position at home or abroad where initiative and drive are essential. Available February 1st, 1955. Write Box 948, Arthur S. Dixon Ltd., 229 High Holborn, W.C.1. W 2370

EDUCATIONAL

BOROUGH POLYTECHNIC, Borough Road, S.E.1. Crystal Valves and Transistors. A course of 10 lectures principally dealing with junction transistors will be given by specialists during afternoons, 3-5 p.m. or evenings 7-9 p.m. on Tuesdays, commencing Tuesday. 19th October, 1954. Fee for the course £2 2s. Fundamental principles of pulse techniques. A course of 20 lectures will be held on Monday evenings 7-9 p.m., commencing Monday, 25th October, 1954. Fee for the course £3 3s. 0d. W 2341

CITY & GUILDS (Electrical, etc.) on "No Pass—No Fee" terms. Over 95 per cent successes. For full details of modern courses in all branches of Electrical Technology send for our 144-page handbook—Free and post free. B.I.E.T. (Dept. 337C). 29 Wright's Lane, London, W.8. W 142

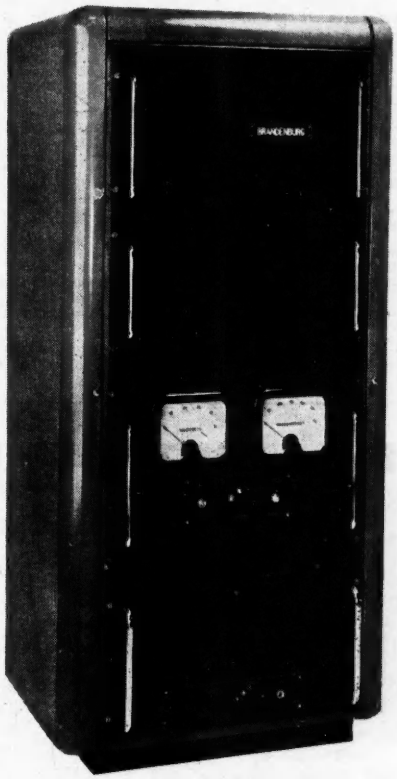
COUNTY BOROUGH OF BOLTON.—Education Committee. Bolton Technical College. Full-time course in Electronic Engineering. A three-year full-time course in Electronic Engineering is now available. Applicants should be between 16 and 18, and have taken, or be

CLASSIFIED ANNOUNCEMENTS
continued on page 10

brandenburg high voltage equipment

a **special** design
to fulfil a
special function

This Brandenburg generator was designed to supply micro-focus x-ray spectrometers, electron-microscopes, and electron diffraction cameras



specification

output

12 KV. — 50 KV. Continuously variable. 3 volts 3 amperes isolated to 50 KV.

stability

Better than 0.1% against mains variation of – 10% and + 5% and load variation of zero to 0.5 MA.

metering

Two 5" Ernest Turner Grade 1 moving coil instruments calibrated in kilovolts and microamperes respectively

From the Brandenburg range of standard and specialized radio frequency and low frequency high voltage equipment

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196 Dawes Road, London, S.W.6 Fulham 1534

EDUCATIONAL (Cont'd.)

taking General Certificate at the Ordinary Level in Mathematics or Physics, or equivalent courses in technical institutions. This rapidly developing industry offers new and attractive openings to qualified men. Application forms and particulars may be obtained from the Principal, Technical College, Bolton, Lancashire. W 3167

FREE Brochure giving details of courses in Electrical Engineering and Electronics, covering A.M.Brit.I.R.E., City and Guilds, etc. Train with the Postal Training College operated by an Industrial Organisation. Moderate fees. Dept. EE29, E.M.I. Institutes, London, W.4. W 190

LECTURERS BATTERSEA POLYTECHNIC, London, S.W.11. Electrical Engineering Department. A one year evening course comprising lectures, tutorials and practicals on Linear Servomechanisms by Mr. J. Lubbock, B.Sc. (Eng.) (Lond.), Mr. R. A. King, M.A., (Cantab.), under the direction of Dr. G. L. d'Ombrain, Ph.D., D.I.C., A.C.G.I., M.Am.I.E.E., M.I.E.E., Consultant and Head of Department. Commences on the 4th October at 7.0, p.m. and on successive Monday evenings through the session. Particulars and enrolment forms on application to the Department. W 2359

THE POLYTECHNIC, Regent Street, London W.1. Department of Mathematics and Physics. Advanced Electronics. The following series of lectures will be held on Fridays from 7-8.30 p.m. commencing 1st October, 1954. A. Principles of Servomechanisms., 1st October to 5th November, 1954. B. Instrument Servomechanisms, 12th November to 17th December. 1954. C. The Physics of Semiconductors. 14th January to 25th February, 1955. D. Semiconductor Circuit Elements, 4th March to 1st April, and 22nd and 29th April, 1955. Fee for each series £1. Composite fee for all series £3 Applications for prospectuses and enrolment forms should be made to the Head of the Department as early as possible. W 2334

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PATENTS

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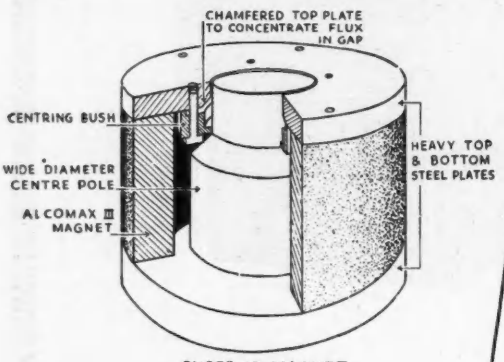
Letter from SOUTH AFRICA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After reading your chapter on sand-filled panels I discovered that a Firm in Cape Town was specialising in Hi-fi equipment, W.L. Proctor (Pty) Ltd.

I am now the proud owner of a 9 cu. ft. reflex enclosure housing your W15/CS with the middle and treble units facing upwards, Super 8/CS and Super 5/CS/AL. The room is furnished with essentials only, placed against the walls. The timber used in the sand-filled panel is Imbuia, a hardwood. The top is of the same wood.

My old records have taken on a new lease of life and I now hear music sounds which have lain buried in the records all these years. My head still whirls when I hear the full natural depth of the piano notes flowing into the room, the violin, the full orchestra, Kathleen Ferrier in her Bach and Handel Arias . . . an experience I would have travelled half way round the world to enjoy. I now hear more detail from some of the LP operas than I ever heard sitting in opera houses overseas.

My long-awaited entry into the sphere of natural sound I owe entirely to you by way of your most enlightening book "Sound Reproduction." I can only say thank you again and again.

E.M.

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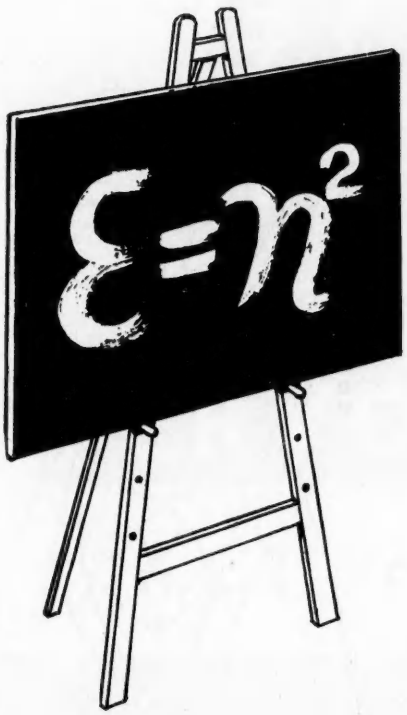

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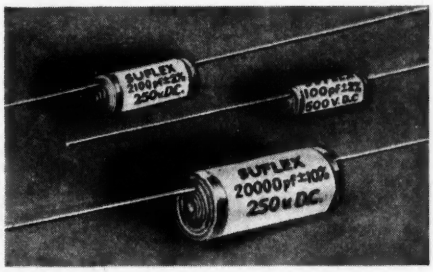

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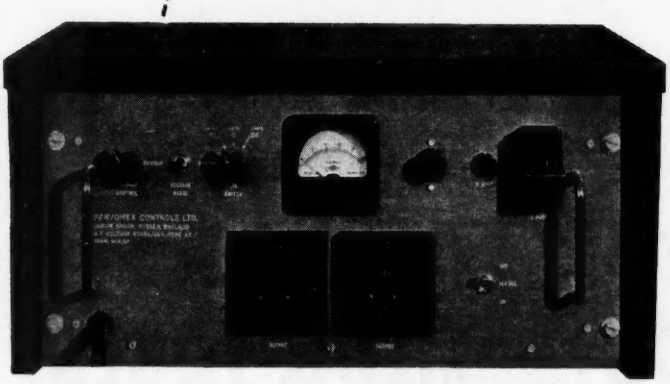

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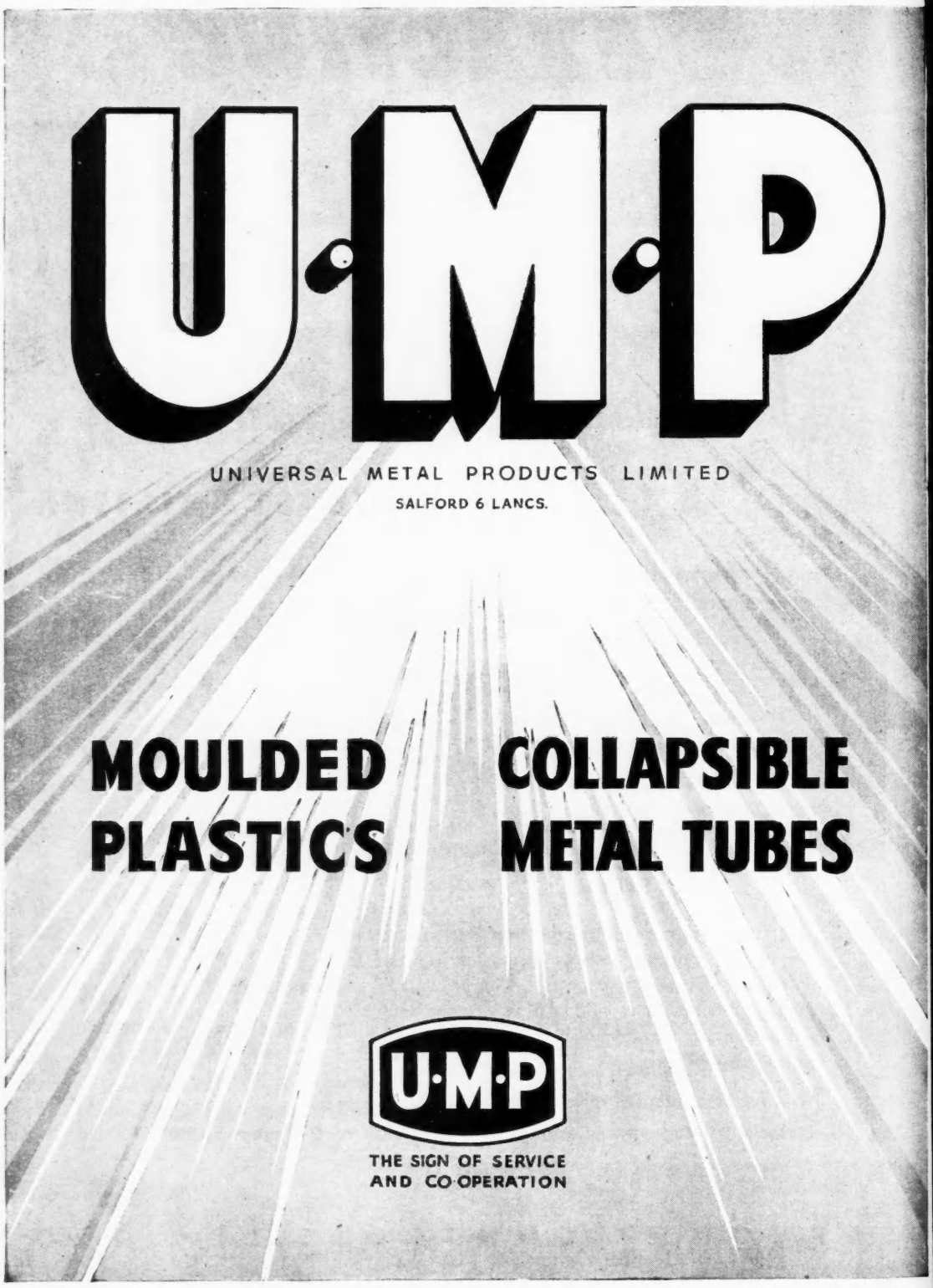
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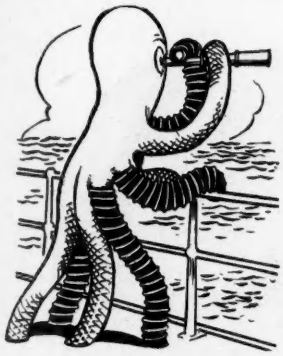

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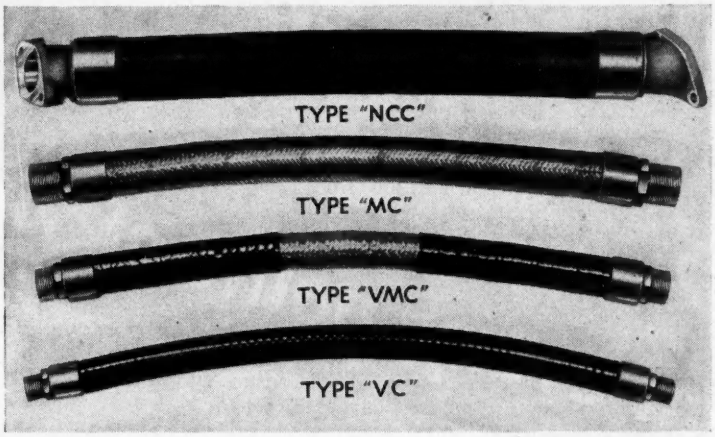

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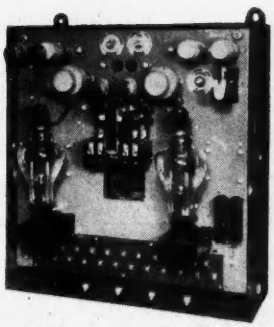
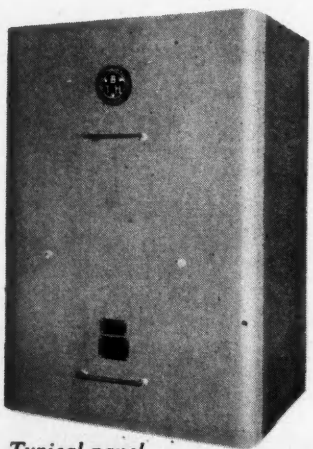
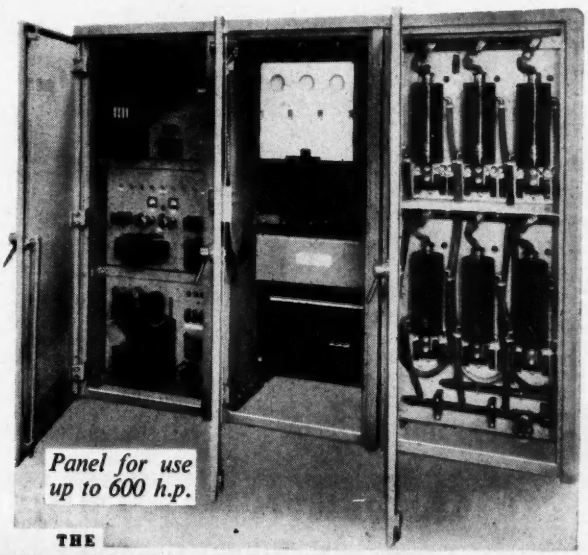


Panel for use from 1/4 h.p. upwards



Typical panel showing enclosure



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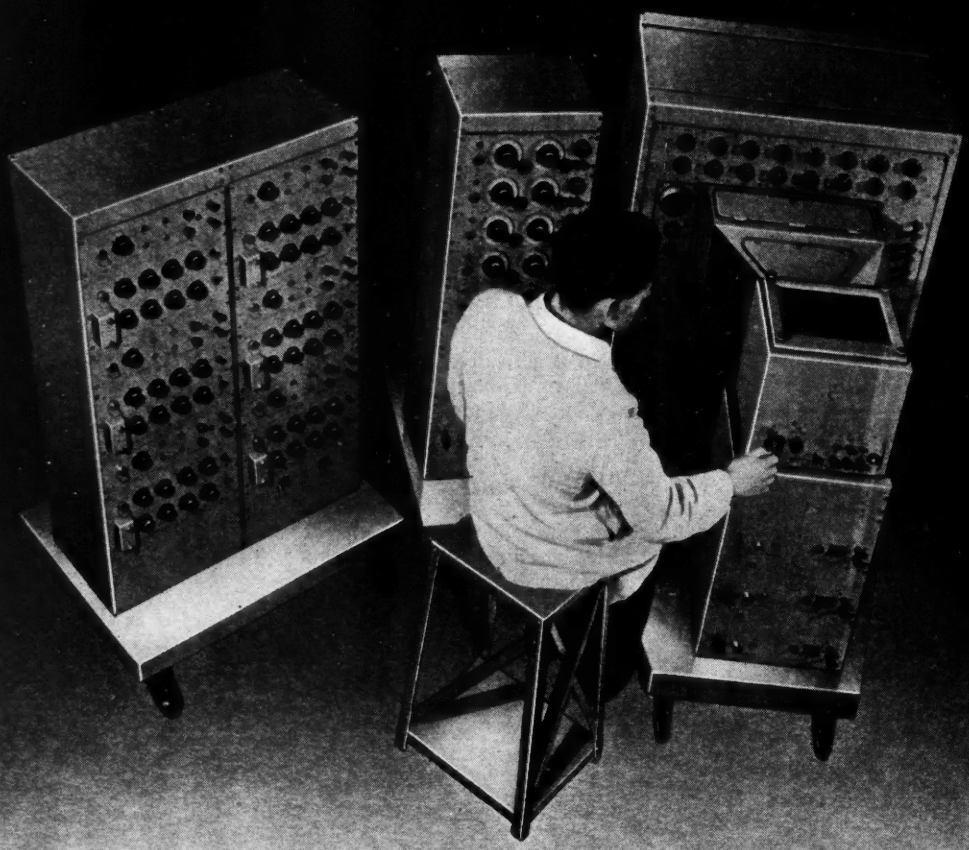

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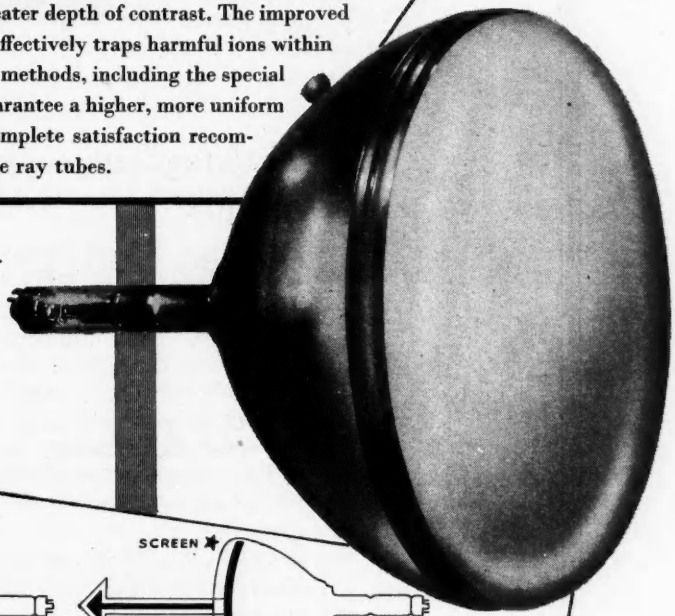

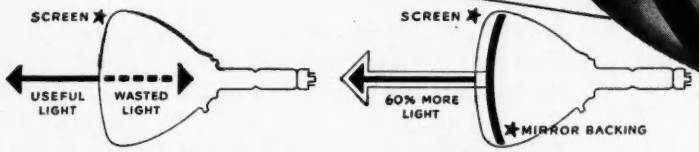

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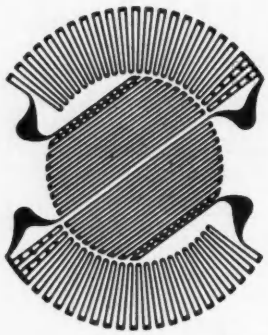

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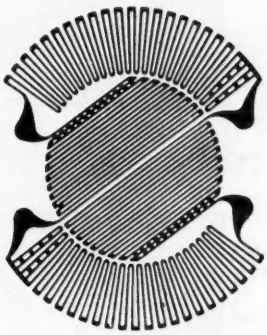

Technograph patents throughout the world now cover various alternative processes, but basically all, together with the numerous applications still pending, are concerned with the production of electrically conductive patterns either by etching metal foil previously laminated to any of the many types of insulating base, or the etching of foil patterns from metal insulated on one side by means other than laminating or bonding.

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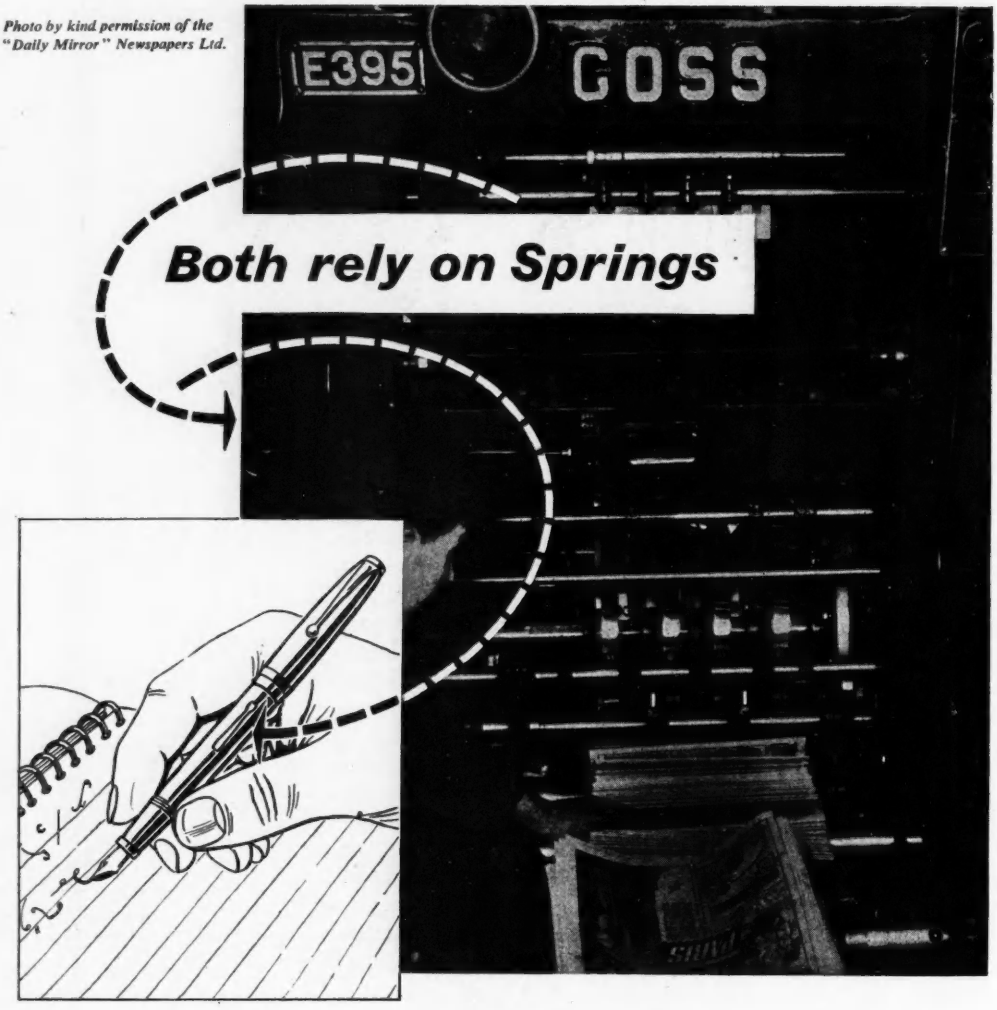

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HIGH STABILITY RESISTORS					
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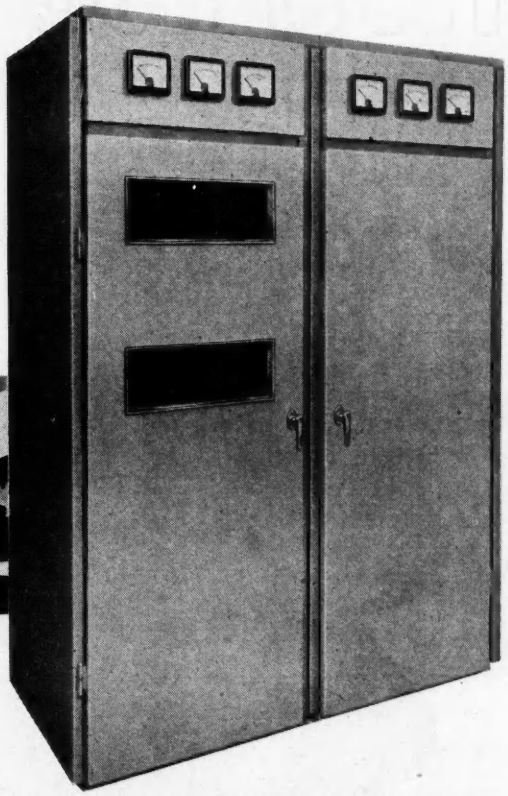

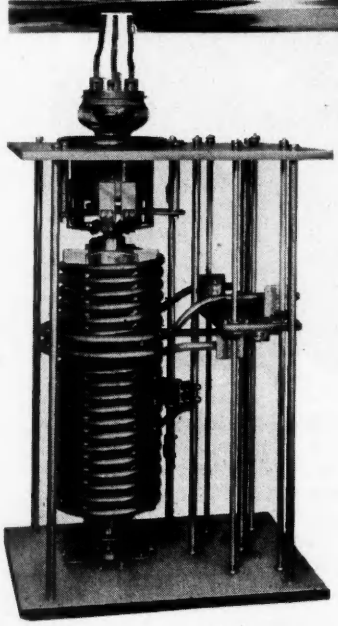

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COMPLETE COMMUNICATION SYSTEMS

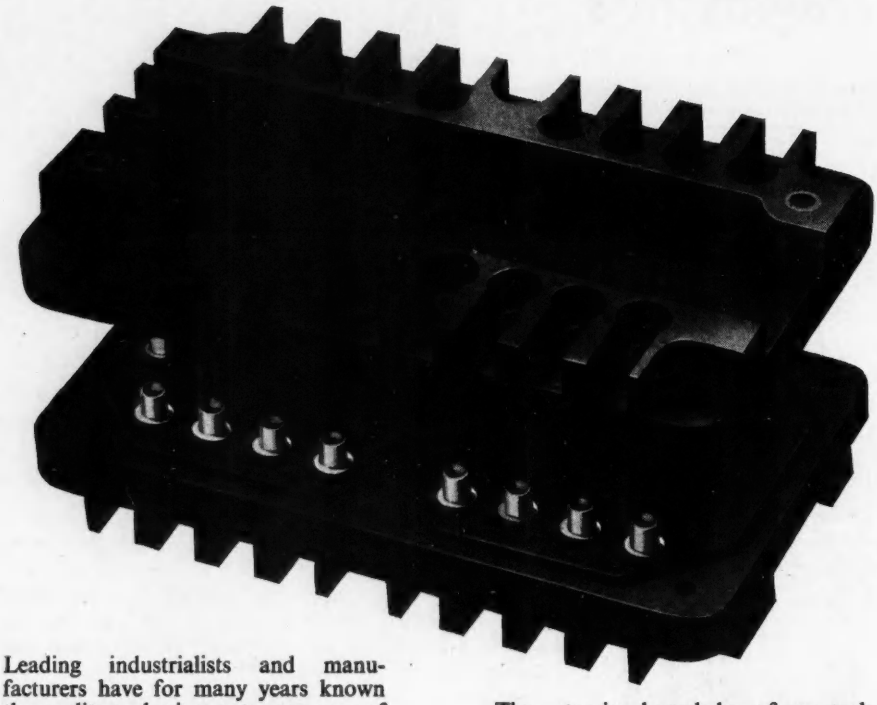
Surveyed, planned, installed, maintained

MARCONI'S WIRELESS TELEGRAPH CO. LTD. · CHELMSFORD · ESSEX

LC.1

INGENUITY with PRECISION

IN MOULDED PLASTICS



Leading industrialists and manufacturers have for many years known the quality and micrometer accuracy of PRESTWARE precision moulded components. A less widely appreciated side of the PRESTWARE organisation is our Technical Advisory Division, whose services are at your disposal to solve your specific moulding problems and suggest fresh uses and applications.

The extensive knowledge of our technicians can save you both time and money; they will design and manufacture for you the most intricate components and piece parts with the finest of tolerances and of a reliability on which the House of PRESTWARE has built its high reputation.

Approved suppliers to H.M. Government

Prestware Ltd.

LOMBARD ROAD, LONDON, S.W.19

Telephone: LIBerty 3421

The *NEW* Muirhead-Wigan decade oscillator

TYPE D-650-A

THIS precision laboratory oscillator, which covers a range of 1 to 111,100c/s with an overall frequency accuracy of ±0.2% or ±0.5c/s, employs the decade tuning system, by means of which the frequency can be set quickly and accurately on four decade dials and a range switch. This system of tuning ensures the highest possible frequency accuracy and stability. It also enables a given frequency setting to be repeated exactly, and permits the addition or subtraction of a fixed number of cycles per second, thus giving an incremental accuracy of an extremely high order. No other type of oscillator possesses all these advantages.

FEATURES

Frequency range: 1-11,110c/s and 10-111,100c/s.

Frequency accuracy: ±0.2% or ±0.5c/s.

Hourly frequency stability: ±0.02% over most of range.

Maximum output:
2W into 8000 ohms above 20c/s.
50mW into 8000 ohms below 20c/s.

Harmonic content: 1% at 1W output.

Hum level: —80db relative to maximum output at 1000c/s.

Power supply: 200-250V, 50c/s; 90W. or 95-125V, 60c/s; 90W.

Dimensions: 17¼ in. wide x 10½ in. high x 13 in. deep. (43·8 cm x 26·7 cm x 33 cm).

Weight: 83 lb. (38 kg).

MAIL THIS COUPON FOR DESCRIPTIVE BROCHURE

NAME_____

POSITION_____

COMPANY_____

ADDRESS to which BROCHURE should be sent

_____

_____

114

MUIRHEAD & CO. LIMITED · BECKENHAM · KENT · ENGLAND

AC sorensen VOLTAGE REGULATOR

— a precision instrument of outstanding performance

MODEL L.T.-1000-2S

- Reliability
- Exceptional accuracy
- Not affected by frequency
- Low distortion
- Fast response time
- No load to full load performance
- Excellent finish and fine workmanship throughout

Specification

RATING	1 KVA
INPUT VOLTAGE	190-260
INPUT FREQUENCY	50 c/s ± 10%
OUTPUT VOLTAGE	220-240 (adjustable)
REGULATION ACCURACY	±0.1% nom.
RECOVERY TIME	0.1 secs.
HARMONIC DISTORTION	3% nom.
P.F. RANGE	Unity to 0.7
LOAD RANGE	No load to full load

Manufactured under licence by:—

J. LANGHAM THOMPSON LTD.

BUSHEY HEATH · HERTS.

Telephone: BUShey Heath 2411 · Grams and Cables: "Tommy Watford"

JLT GROUP

TRANSDUCERS

for the measurement of

SURGE, FLUCTUATING OR STEADY PRESSURES

(Gauge or Differential)

FOR SURGE, FLUCTUATING OR STEADY PRESSURES

TYPE NO. 448 *(as illustrated)*
0 - 1000 p.s.i. to 0 - 50,000 p.s.i.

TYPE NO. 449
0 - 10 p.s.i. to 0 - 1,000 p.s.i.

Both the above types comprise a 4-arm strain gauge compensated bridge, producing a voltage output (m.V.) directly proportional to the applied pressure.

TYPE NO. 522 0 - 15 p.s.i. to 0 - 2,500 p.s.i.

Pressure is applied to a diaphragm which is caused to change the inductance of an iron cored circuit. This change of inductance can then be used either to create out-of-balance in a bridge or to frequency modulate an oscillator.

FOR STEADY OR SLOWLY FLUCTUATING PRESSURES

TYPE NO. 548
0 - 5 p.s.i. to 0 - 4,000 p.s.i.

Comprising a Bourdon tube or bellows operating a precision potentiometer. These transducers produce a voltage output directly proportional to pressure.

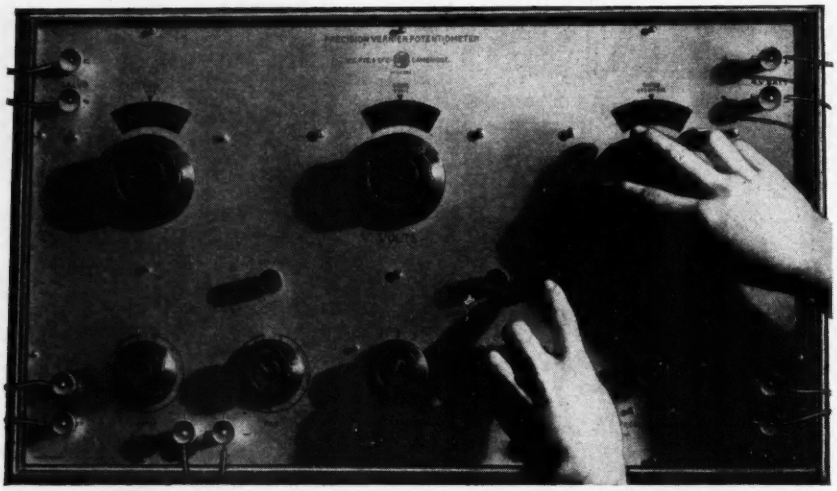
JLT GROUP

Manufactured by :—

J. LANGHAM THOMPSON LIMITED

BUSHEY HEATH · HERTS

Telephone : Bushey Heath 2411 · Grams and Cables : "Tommy Watford"



Built by Craftsmen . . . . . . *Pye Precision Vernier Potentiometer*

ACCURACY WITHIN YOUR GRASP

Designed for measurements of a very high order of accuracy, this VERNIER potentiometer is being used extensively for the accurate measurement of resistance, as a standard for calibrating potentiometers, meters and other electrical measuring instruments, for measuring thermo-couple voltages and for many applications of a similar nature. Through every stage of its manufacture the most careful precautions are taken to eliminate possible sources of error.

Please write for details of our range of precision potentiometers which also includes a SLIDE-WIRE type reading to 1 microvolt with an accuracy of .02% as well as a PORTABLE type which is completely self-contained, compact, robust and always ready for immediate use.

Our new catalogue giving details of our comprehensive range of Galvanometers, Shunts, Standard Cells and other precision measuring instruments is available on request. May we please send you a copy?

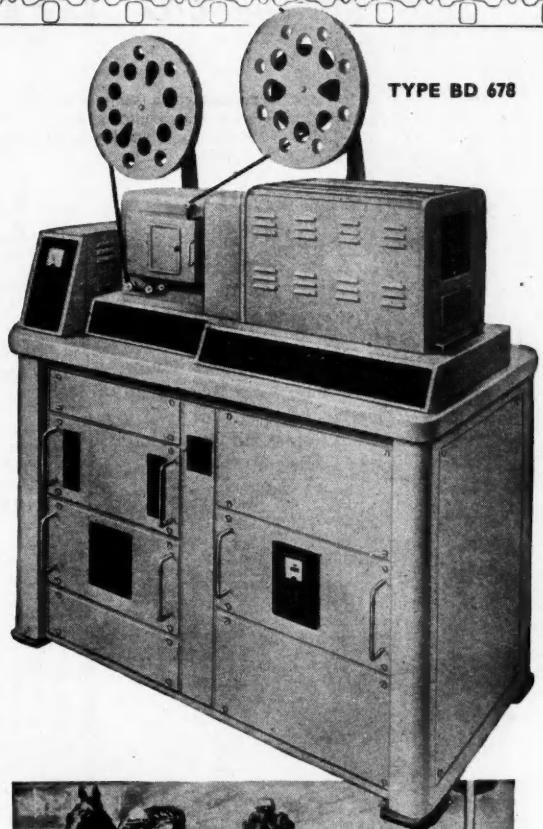
STANDARD EQUIPMENT IN MANY LEADING LABORATORIES

SCIENTIFIC PYE INSTRUMENTS

W. G. PYE & CO. LTD., GRANTA WORKS, CAMBRIDGE, ENGLAND

WG.56

Flying Spot Telecine Equipment



TYPE BD 678

The equipment provides a television picture of exceptionally high quality from 16 mm. films and 2 x 2 in. miniature film slides. A 'fast pull down' type of film projector is used and a similar mechanism serves for television systems having field repetition rates of either 50 or 60 fields per second. Thus any type of fixed or moving prism system is obviated.

The 16 mm. Projector, Turret Slide Scanner, Optical Change-over Assembly, Flying Spot Scanning Unit and the PEC Amplifier are mounted on top of the steel cabinet which houses the auxiliary units and power units.

The equipment can be fully controlled locally and remote controlled for stopping and starting of the film projector, change-over from film to slides and selection of any one of eight slides.

Editions of the BD 678 are available for 405, 525, or 625 line systems

MARCONI

Complete Broadcasting and Television Systems

Marconi Equipment has been installed in every one of the B.B.C. Television transmitter stations and in the U.S.A., South America, Canada, Italy and Thailand

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED · CHELMSFORD · ESSEX

LB 2

TIME *to change . . .*

. . . to a really first-class new instrument which is now offered to research and development workers. The New Nagard Oscilloscopes represent years of accumulated experience in this field. The instruments illustrated show two extremes of a wide range of Oscilloscopes employing so many advances in design and construction that a completely new standard has been reached.

MODEL M201

For **High Speed Transients** or pulses—single stroke to 20 Kc/s p.r.f.

Sweep speed up to 25 cms/μsec on 6" CRT.

Calibrated time measurement plus sweep expansion × 5.

D.C. Y Amplifier—0.02 μsec **rise time** critically damped—sine wave response 0—25 Mc/s. High impedance input and built-in delay line.

Input voltage calibration from 0.2 to 120 v. or to 6000v. via high voltage attenuator.

Sensitivity 5 mm/volt peak to peak.

Unit Construction—rugged, accessible and mobile.

MODEL DS103

A Double Gun D.C. Oscilloscope of great versatility at modest cost.

Wide Range Time Base with extra slow speed range continuously variable **calibrated** sweep times from 2 sec/cm to 20 μsec/cm, plus **sweep expansion** × 5 on either or both beams. Reliable triggering. Time measurement to 5% accuracy over range of 20 secs to 20 μsec.

Independent X Shift on each beam.

X Amplifier and Beam blanking switch incorporated.

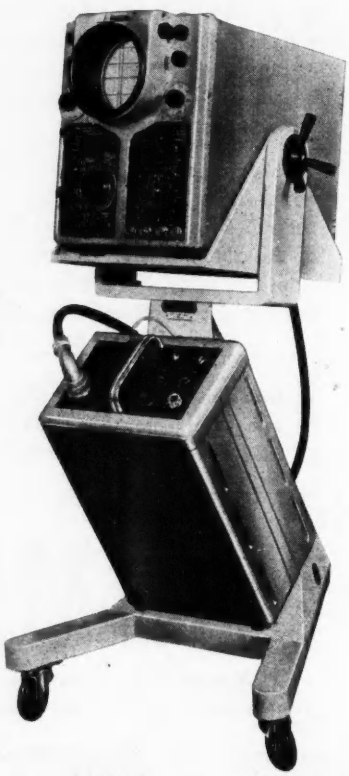
Dual Channel D.C. Y Amplifiers—0—200 Kc/s (—3dB) providing identical conditions on each gun system.

Balanced high discrimination inputs. Low microphony.

Sensitivity 8 mV/cm peak to peak, or with pre-amplifier, the display of signals down to the 20 μV level.

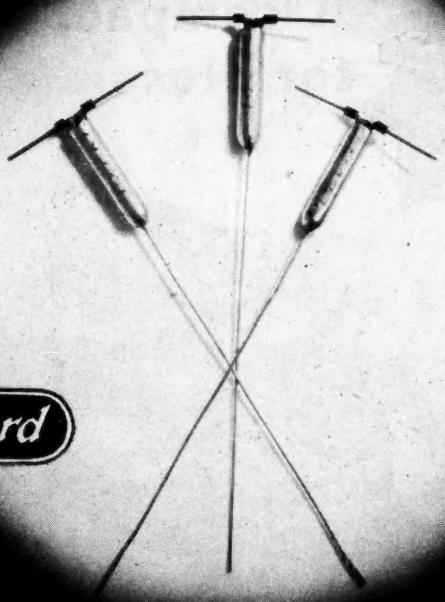
Voltage measurement to 5% from 10 mV to 500v.

6" C.R.T. with illuminated graticule.



NAGARD LTD. · **18 AVENUE ROAD** · **BELMONT** · **SURREY** · **VIGilant 0345**

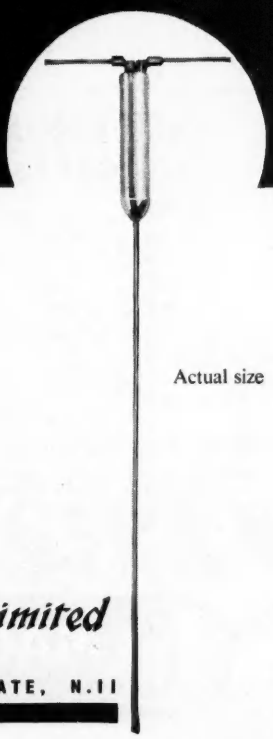
Now available...



Standard

high-grade

TRANSISTORS



Actual size

Pioneers in semi-conductor development and manufacture **Standard Telephones and Cables Limited** were also first to produce transistors in Europe.
Two types of germanium point contact transistors are now available for immediate delivery.

Code 3X/100N—for control and switching circuits.

Code 3X/101N—for use as an amplifier or oscillator.

Enquiries are also invited for *Standard* Junction type transistors.

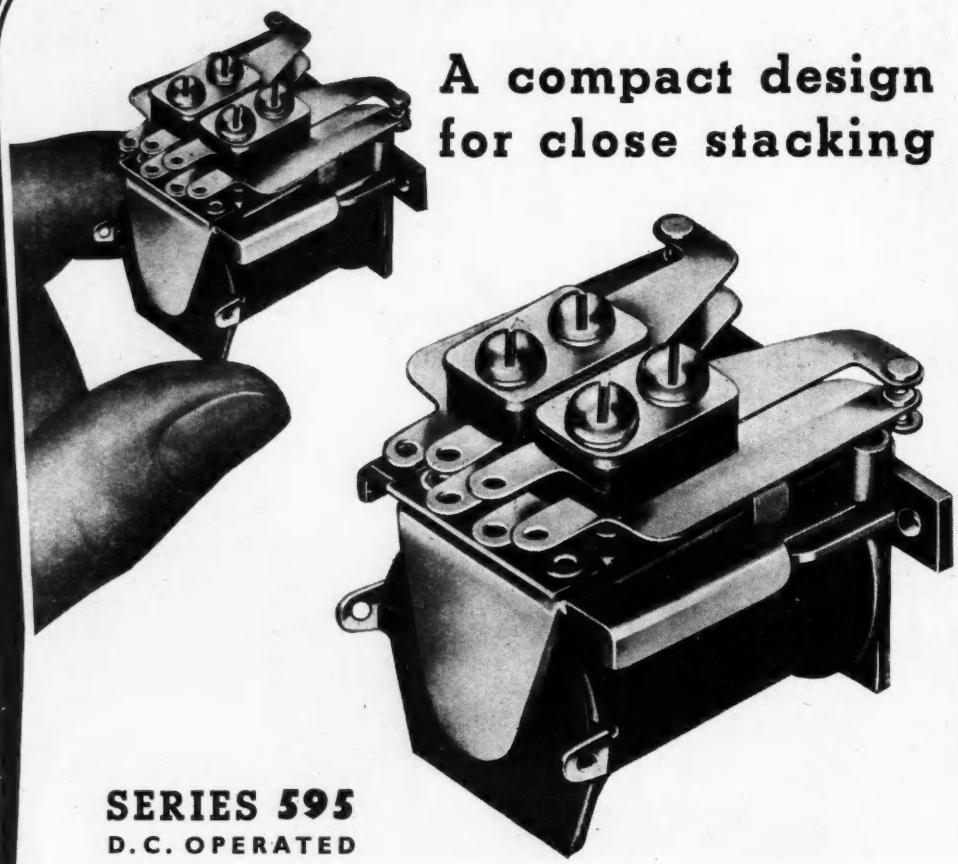
Standard Telephones and Cables Limited

(Registered Office: Connaught House, Aldwych, London, W.C.2.)

RADIO DIVISION, OAKLEIGH ROAD, NEW SOUTHGATE, N.11

RELAYS

A compact design for close stacking



SERIES 595
D.C. OPERATED

This extremely compact relay has its connections to both contacts and coil brought conveniently to one end, and is designed without projections to facilitate close stacking where banks of Relays are in use. The contact current handling capacity is exceptionally high in relation to the overall dimensions of the Relay. Good armature design has reduced the effects of shock, vibration and acceleration, and the spring type hinge eliminates backlash friction and risks of displacement.

For further details of our range please write.

TELEPHONE : NEWMARKET 3181-2-3 TELEGRAMS : MAGNETIC NEWMARKET

MAGNETIC DEVICES LTD
NEWMARKET

MD 1A

PRICE REDUCTION

12E1 BEAM TETRODE

NOW £2 *LIST*

Increased demand for the Ediswan Mazda 12E1 Beam Tetrode has enabled us to step up production and thereby offer a reduced list price.

The 12E1 has the unusually high maximum cathode current rating of 300mA with a screen voltage of 150V. Mutual conductance is 14mA/Volt. It is, therefore, very suitable as a series or shunt valve in stabilised power packs. It also finds application in electronic control and other circuits.

RATING

Heater Voltage (volts)	V_h	6.3
Heater Current (amps)	I_h	1.6
Maximum Anode Voltage (volts)	$V_{a(max)}$	800
Maximum Screen Voltage (volts)	$V_{g2(max)}$	300
Maximum Control Grid Voltage	$V_{g1\ (max)}$	100
Maximum Voltage between g1 and g2 (volts)	V_{g1-g2}	400
Mutual Conductance (mA/V)	S_m	* 14
Inner μ	$\mu_{g1,g2}$	* 5.3
Maximum Anode Dissipation (watts)	P_a	35
Maximum Screen Dissipation (watts)	P_{g2}	5.0
Maximum Cathode Current (mA)	$I_{k(max)}$	300
Maximum Potential Heater/Cathode (volts DC)	$V_{h-k(max)}$ †	300

* Taken at Va = Vg2 = 150v Ia = 200 mA.

† Provided the cathode is positive

All maximum ratings are Absolute values not Design Centres.

Reduced prices also for

19H4 to **£5.0.0**

19H5 to **£8.0.0**

Full technical information available on request

EDISWAN

MAZDA

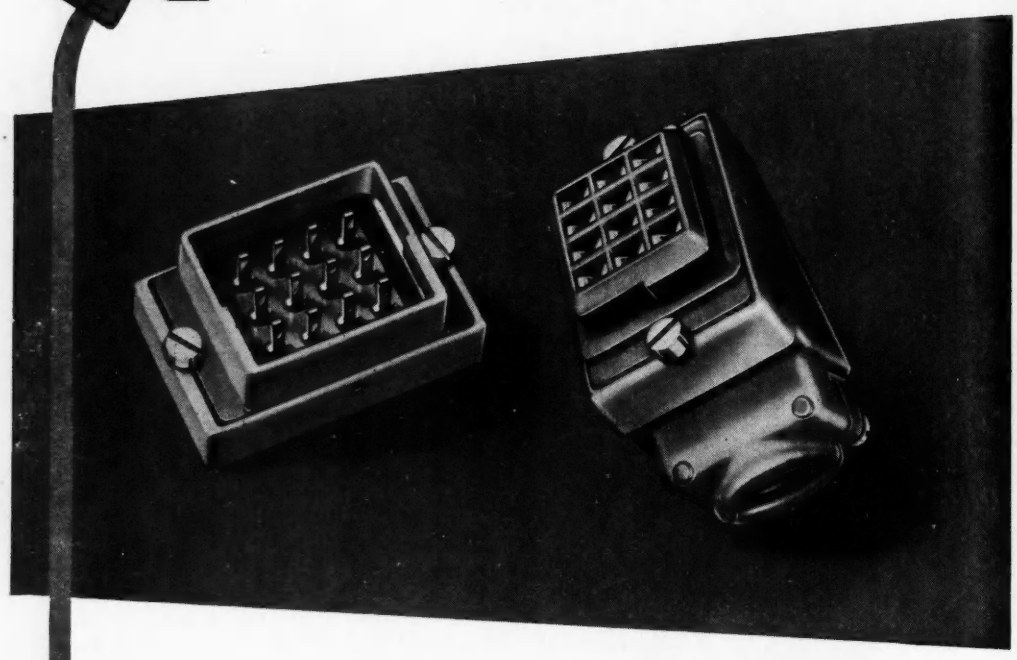
RADIO DIVISION · THE EDISON SWAN ELECTRIC COMPANY LIMITED

155 Charing Cross Road, London, W.C.2. *Telephone:* Gerrard 8660. *Telegrams:* Ediswan, Westcent, London

Member of the A.E.I. Group of Companies

SV2

The performance of only as good as



Multiway Plugs and Sockets for quick action and positive contact

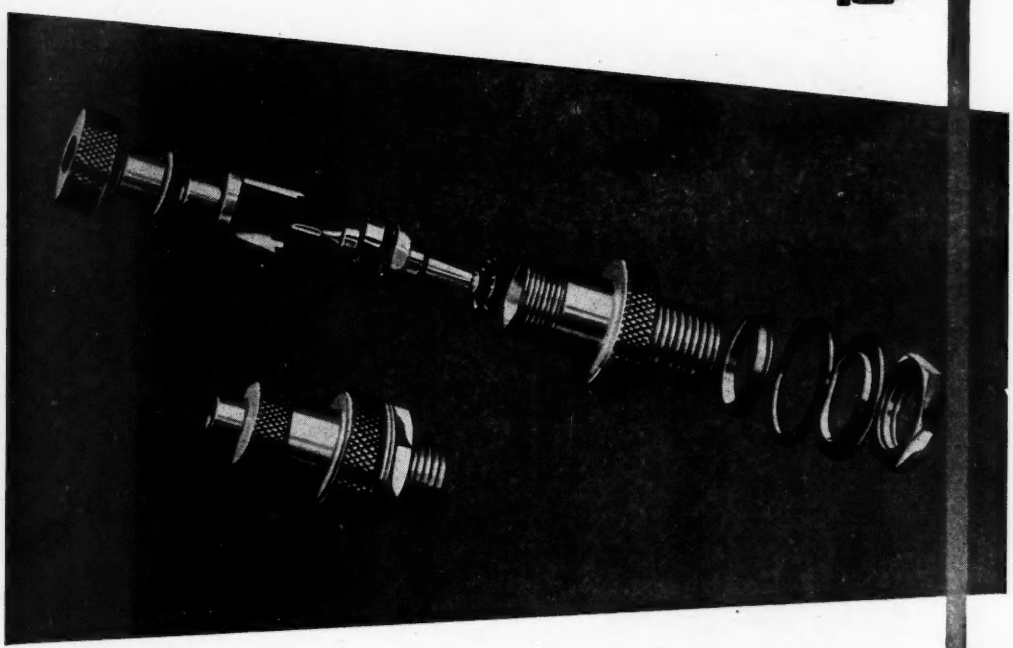
These reliable Plugs and Sockets, proved in service, provide a quick positive connection for up to 28 terminations. They need lower insertion pressure per contact than any comparable product, and when fully mated a dust and damp proof seal is provided between Plug and Socket. Considerable latitude in matching can be allowed when they are used in rack mounting applications.

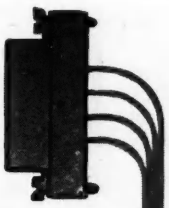
These components are in regular use by :— The English Electric Co. Ltd., Messrs. Marconi's Wireless Telegraph Co. Ltd. and Messrs. Standard Telephones & Cables Ltd.

4 WAY · 8 WAY · 12 WAY · 20 WAY · 28 WAY

PLEASE WRITE FOR FURTHER DETAILS TO

any equipment is its terminals





These versatile Miniature connectors provide perfect coupling between co-axial cables and instruments, and are extensively used in Television, Radar, and Communications equipment. They are 100% pressure and flash tested before despatch. The full range consists of a variety of Cable and Panel Mounting units of either plug or socket type, and a recent addition is an elbow connector for applications where it is desired to keep the face of the panel clear. Suitable for use with co-axial cable Uniradio 32 and 43.

Miniature hermetically sealed Co-axial Plugs and Sockets to RCS.322

A.I.D & A.R.B — APPROVED

POWER CONTROLS
LIMITED

EXNING ROAD, NEWMARKET. TELEPHONE NEWMARKET 3181

LEOCAST COMPONENTS AND CIRCUITS

(RESIN ENCAPSULATED)

Leocasting is the specialised process of CASTING OR MOULDING IN RESIN of components or sub-circuits. It embraces such terms as 'Potted Circuits,' 'Moulded Circuits' and 'Resin Cast' or 'Resin Encapsulated' Circuits.

Lion Switchgear Ltd. have perfected the process, and will carry out Leocasting on a prototype or production basis using resins specified by customers or will select one of their own special 'mixes' for the particular application.

Ask for the LEOCAST leaflet for fuller details.

The Special Products Department of Lion Switchgear Ltd. is in a position to undertake the manufacture of Electronic Assemblies and Equipments. Prototypes, large batches or short pre-production runs of equipment can be produced to specification. This service includes the fabrication of the metalwork, electro-plating, spraying and finishing as well as the assembly, wiring and testing. **Ask for the Special Products Leaflet.**

★ EXPORT ENQUIRIES INVITED ★

LION SWITCHGEAR LTD.

ELECTRONICS DIVISION

LION WORKS · HANWORTH TRADING ESTATE
HAMPTON ROAD · FELTHAM · MIDDLESEX

TELEPHONE : FELTHAM 3567 and 2922

THIS UNIQUE

STELLATE CORE IS THE

SECRET OF FAULTLESS FLUXING

... because it gives six points of rapid solder collapse and the flux is liberated *immediately* heat is applied. The correct amount of activated flux is always present in Superspeed, thus eliminating dry or H.R. joints. The stellate core is featured only in the Enthoven range of cored solders which ensures perfect soldering.

Superspeed

ACTIVATED ROSIN CORED SOLDER

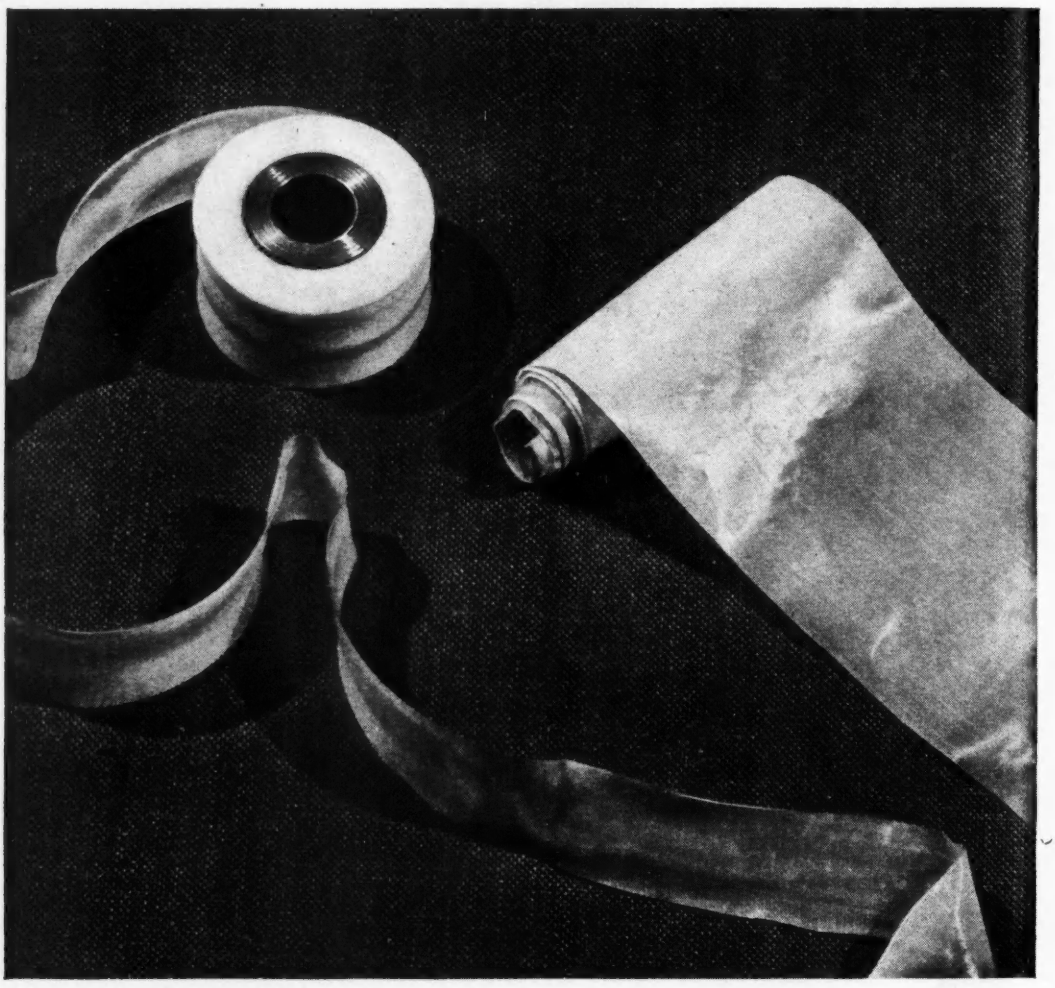
for all Radio, T.V. electronic and telecommunication soldering. Complies with M.O.S. Specification DTD. 599 and is approved by the A.I.D., G.P.O. and R.C.S.C. Superspeed is available in a wide range of alloys and gauges. Samples together with comprehensive literature gladly sent on request. Technical advisers are available for consultation.

MANUFACTURED BY THE **ENTHOVEN** *GROUP*

Marketed by Enthoven Solders Ltd., Enthoven House, 89, Upper Thames Street, London, E.C.4. Telephone : Mansion House 4533

*
B3925

Insulating problems taped!
—with 'FLUON'*



Film and tape manufactured from
'FLUON' polytetrafluoroethylene by Crane Packing Ltd.

'FLUON' tape has outstanding dielectric and insulating properties over a very wide range of frequencies and temperatures —60 to 109 C.P.S. and -80°C to 250°C.

★ *'FLUON' is the registered trade mark for the polytetrafluoroethylene manufactured by I.C.I. Please ask for full technical data.*

IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1

P.573

Track Assembly

Moulded with

'Araldite'

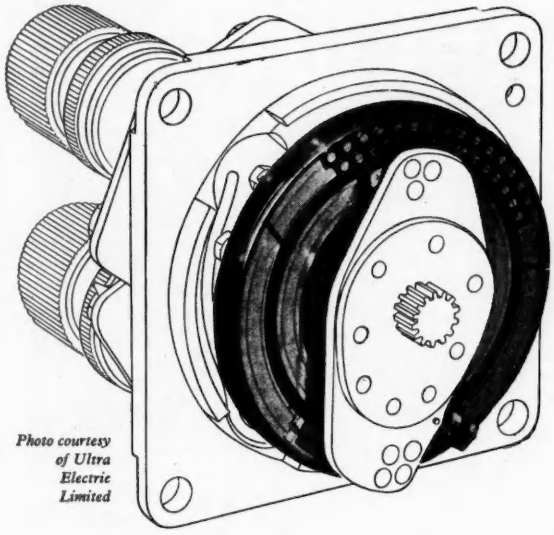


Photo courtesy of Ultra Electric Limited

This selector unit (part of the Ultra Jet Pipe Temperature Control System) controls the temperature of the exhaust gases of a turbo-jet aero-engine.

The resistance elements and track segments are moulded in 'Araldite' Casting Resin B, simplifying assembly and sealing the elements against climatic changes and ensuring mechanical stability.

This is another example of the versatility of 'Araldite' epoxy casting resins which combine exceptionally low shrinkage on setting with resistance to high temperatures, humidity and corrosive agents. 'Araldite' epoxies are facilitating production in many industries—most notably in the potting and sealing of components for radio, electronics and electrical engineering generally.

THESE ARE THE NEW EPOXIES!

'Araldite' (regd.) epoxy resins are obtainable in the following forms:—

- *Hot and cold setting adhesives for metals and most other materials in common use*
- *Casting resins for the electrical, mechanical and chemical engineering industries*
- *Surface coating resins for the paint industry and for the protection of metal surfaces*

Full details will be sent gladly on request.

'Araldite' *epoxy casting resins*

Aero Research Limited

DUXFORD, CAMBRIDGE. Telephone: Sawston 187 A Ciba Company

264-75 A

When it's a question of MINIMUM SIZES...

HUNTS METALLISED PAPER CAPACITORS

HUNTS METALLISED PAPER CAPACITORS
MIDGET MOLDSEAL TUBULARS
TYPE W99

Specification

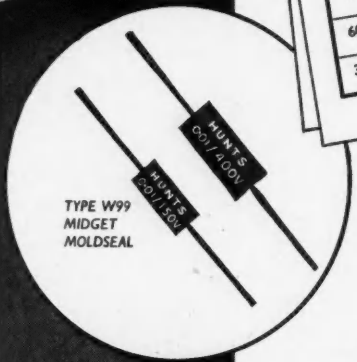
Heat moulded housing ensuring an adequate seal against moisture. Wire leads soldered directly to capacitor unit in a manner ensuring freedom from intermittent contact (strength of joint exceeds tensile strength of wire lead).

RANGES

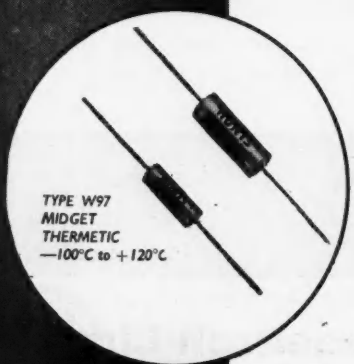
Working Voltage	Temperature Range	Capacitance μF	Size *
150 D.C.	—40°C to + 71°C	0.004 to 0.01 0.02 to 0.04	A B
400 D.C.	—40°C to + 85°C	0.001 to 0.003 0.004 to 0.01	A B
600 D.C.	—40°C to + 85°C	50pf to 0.001 0.002 to 0.004	A B
300 A.C.	—40°C to + 71°C	50pf to 0.001 0.002 to 0.004	A B

SIZES * A = $\frac{1}{16}$" x $\frac{1}{16}$" B = $\frac{1}{4}$" x $\frac{1}{16}$"

Capacitance Tolerance: Standard ± 20% (Closer tolerance available)
Insulation Resistance: 20,000 megoh[illegible] working voltage
Power Factor [illegible] than 2% at 1,0[illegible] per second at 20°



TYPE W99
MIDGET
MOLDSEAL



TYPE W97
MIDGET
THERMETIC
—100°C to + 120°C

Look to HUNTS!

For maximum reliability. Hunts capacitors for radio and electronic equipment include many types designed to meet the need of designers for decreased dimensions.

Type W99 listed above is just one example taken from Hunts unparalleled range of capacitors for every purpose.

Years of specialisation in nothing but capacitor design and manufacture has enabled us to achieve and maintain that long-lasting reliability, and outstanding performance which characterises every Hunt product.

Please write for leaflet giving full details of types for all applications.

REGISTERED TRADE MARK
HUNTS
CAPACITORS
THE TRADE MARK OF RELIABILITY
Established 1901

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and in Canada HUNT CAPACITORS (Canada) LIMITED, AJAX, ONTARIO

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AVO VALVE CHARACTERISTIC METER
AVO ELECTRONIC TESTMETER
AVO UNIVERSAL BRIDGE
AVO ELECTRONIC TEST UNIT
THE D.C. AVO MINOR
AVO WIDE RANGE SIGNAL GENERATOR
HEAVY DUTY AVO METER
UNIVERSAL AVO MINOR
UNIVERSAL AVO METER
Precision ELECTRICAL MEASURING INSTRUMENTS
See us at the
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SEPTEMBER 4th
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You can depend on "Avo." When choosing instruments, consult our complete catalogue, a copy of which may be had free on application
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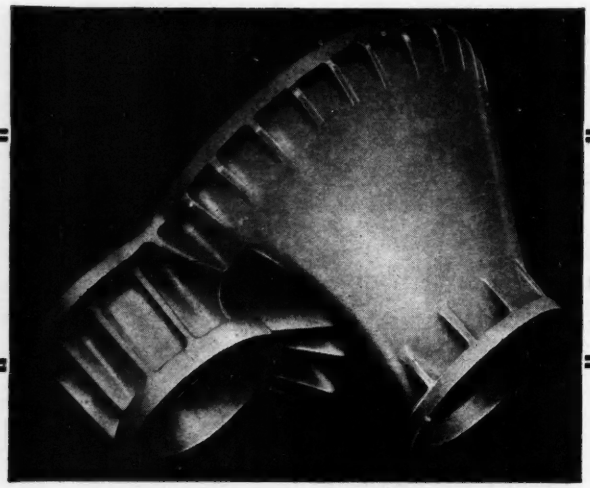

Casting in Aluminium Alloy (approx. weight 208 lbs.)

C.&L.HILL LTD

Manufacturers of

Non-Ferrous Sand Castings, Brass, Naval Brass, Brazing Metal, Gunmetal, Phosphor Bronze, Aluminium Bronze, High Tensile Manganese Bronze, High Conductivity Copper, "Hilchil" Chill Cast Phosphor Bronze Bars, Cored and Solid.
Sand Castings in all Aluminium Alloys, including Heat-treated Alloys, Aluminium Alloy Gravity Die Castings.

Wood and Metal Pattern Shop. Fully Approved Laboratory and Test House with Inspection Organization. Facilities for Radiology.
Specialists in Development and Quantity Production of Castings for Radar.

We solicit your enquiries for
SHELL MOULDED CASTINGS
in all non-ferrous Alloys, including Aluminium

C.&L.HILL LTD

Stringes Lane, Willenhall, S. Staffs.

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Grams: Hill 227 Willenhall
Branch Works: Wednesfield Road, Willenhall

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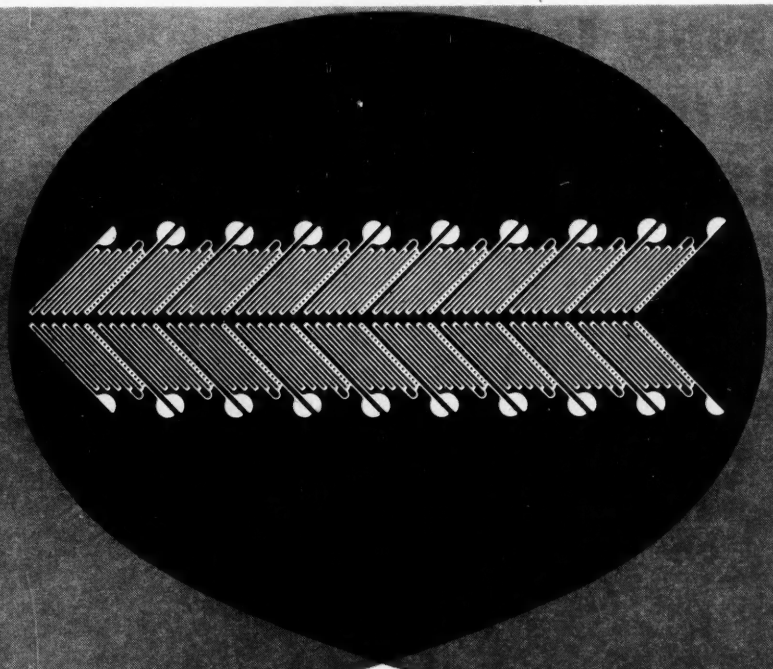

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British and Foreign Patents pending

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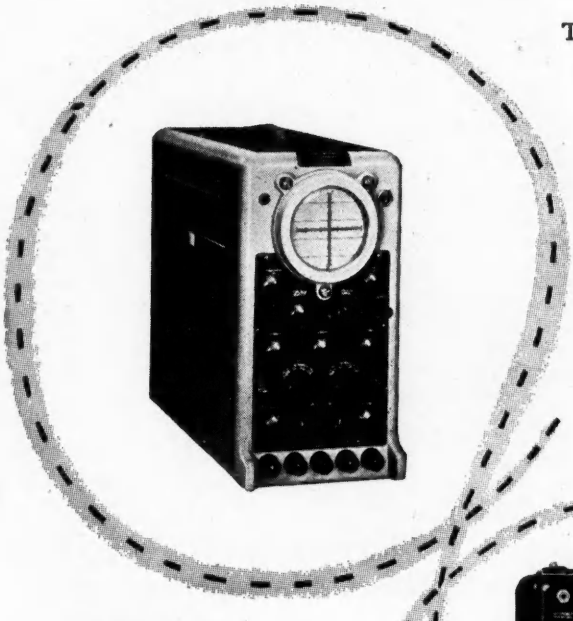
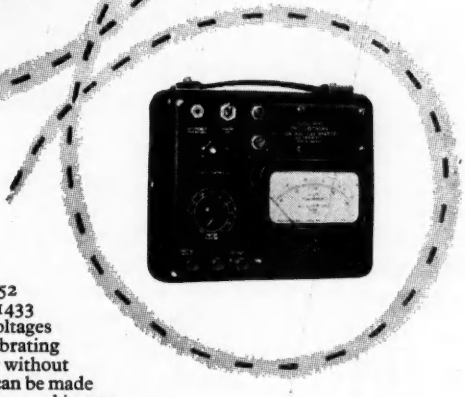
COSSOR presents Model 1052 double beam oscillograph



Two similar amplifier channels with an approximate gain of 2000 and an upper frequency response of 5 megacycles (—6DB) are features of this new Cossor Double Beam general-purpose oscillograph. The repetitive or triggered time base has a sweep duration from 200 milliseconds to 5 microseconds.

The instrument will operate from power supplies of any of the various frequencies and voltages encountered in the Armed Services or from standard civil supply mains.



and Model 1433 voltage calibrator

Primarily designed to be used with the Model 1052 oscillograph the Cosser Voltage Calibrator Model 1433 provides an accurate means of calibration of input voltages to the plates or amplifiers of any oscillograph. Calibrating voltages are read directly from a wide scale meter without any computation being necessary. Measurements can be made to an accuracy of ± 5% and the instrument can be used in any application where a source of accurately-known voltage is required.

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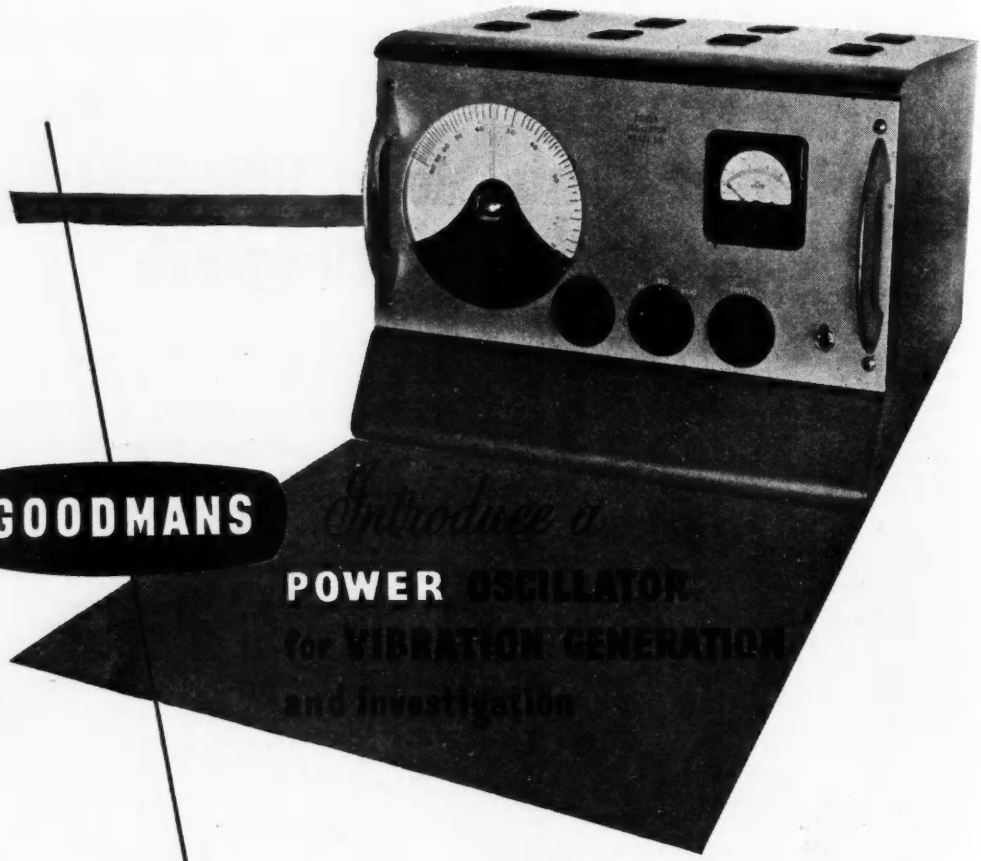

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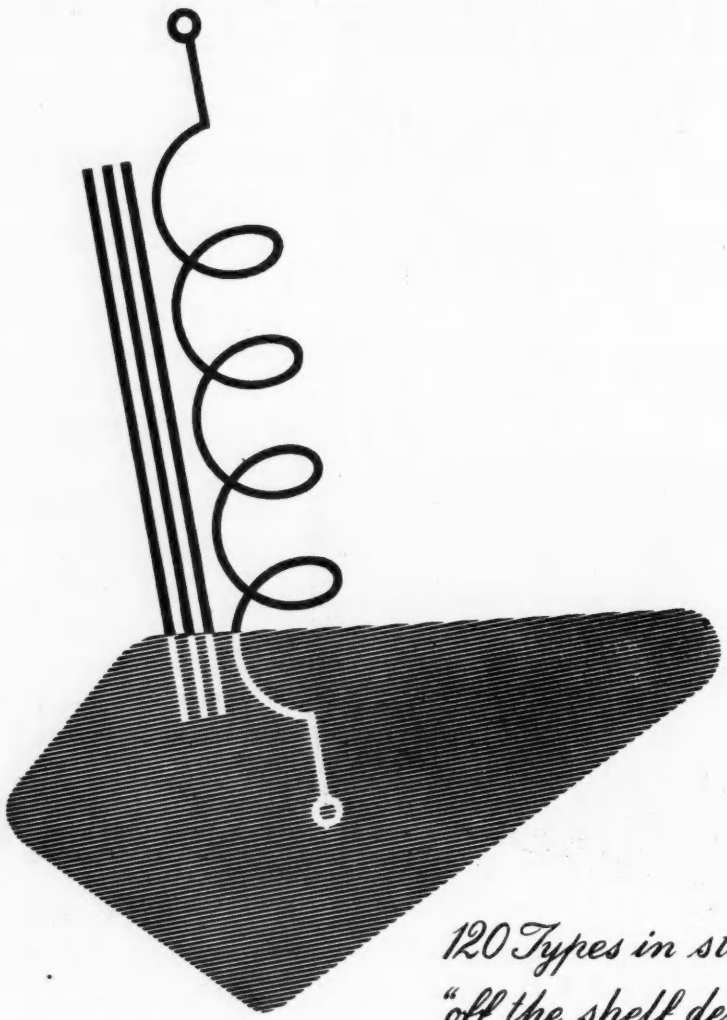

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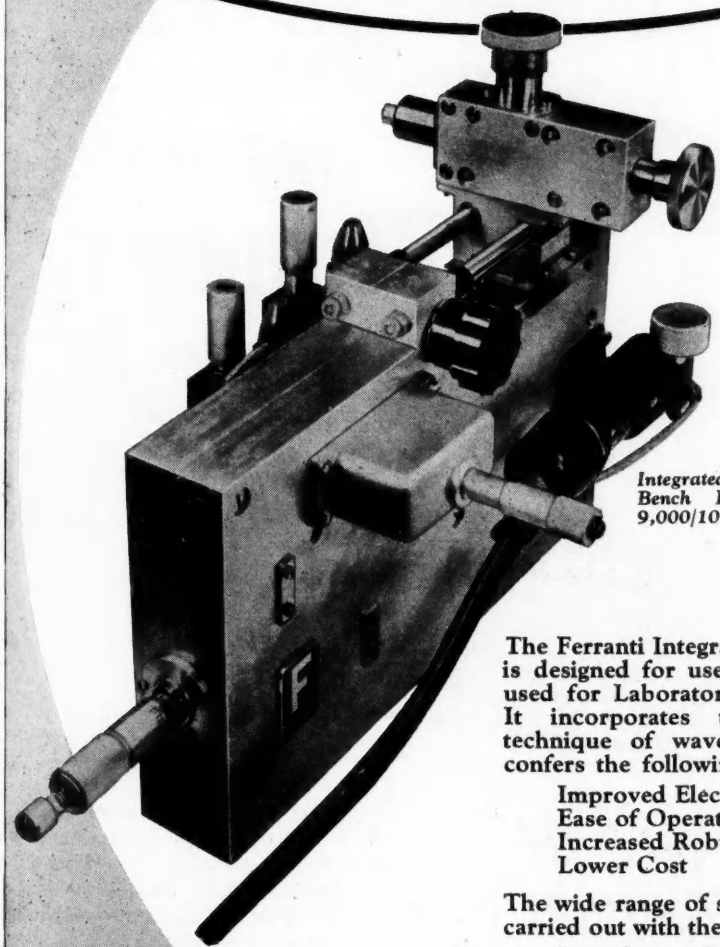

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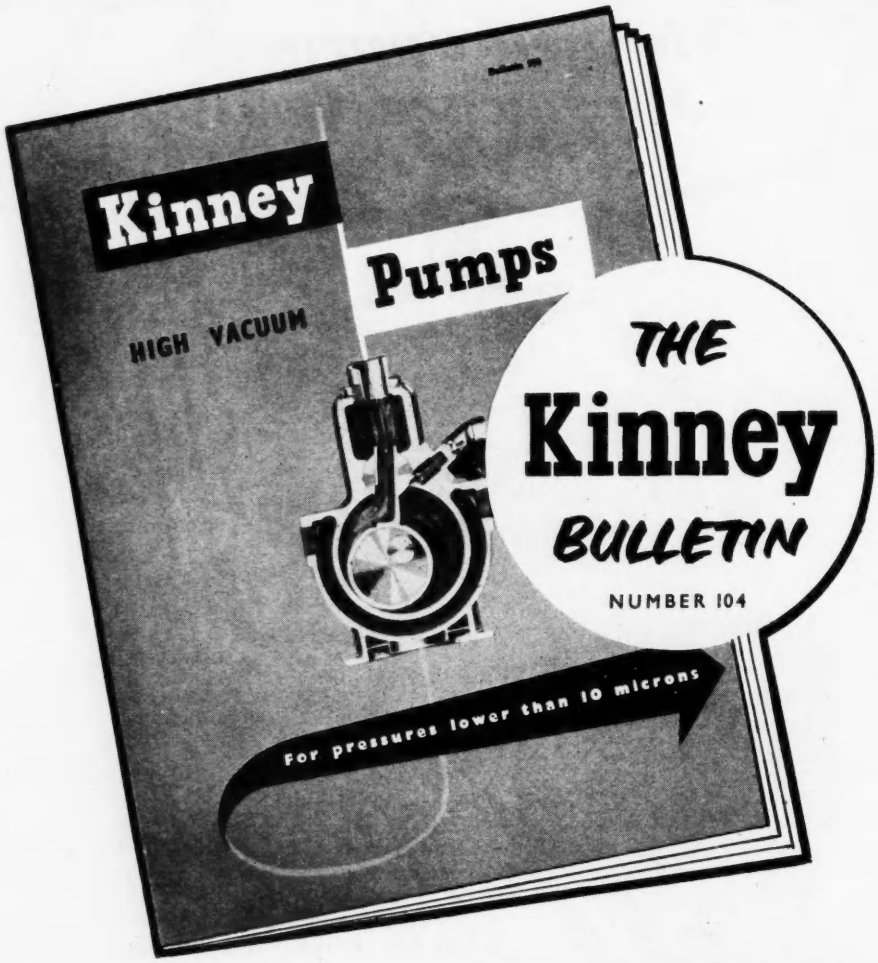

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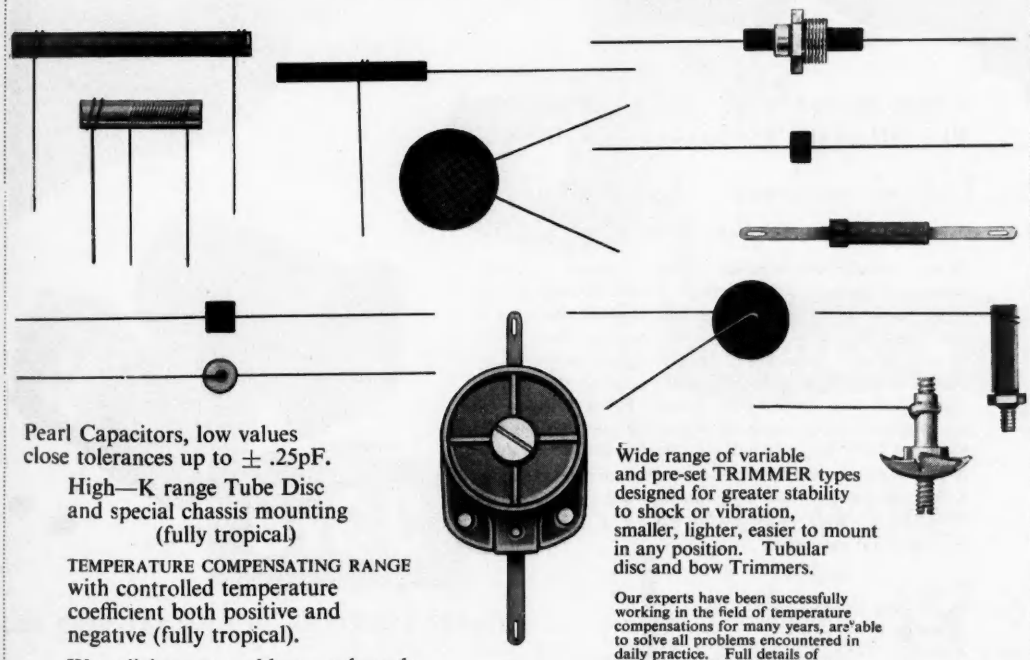

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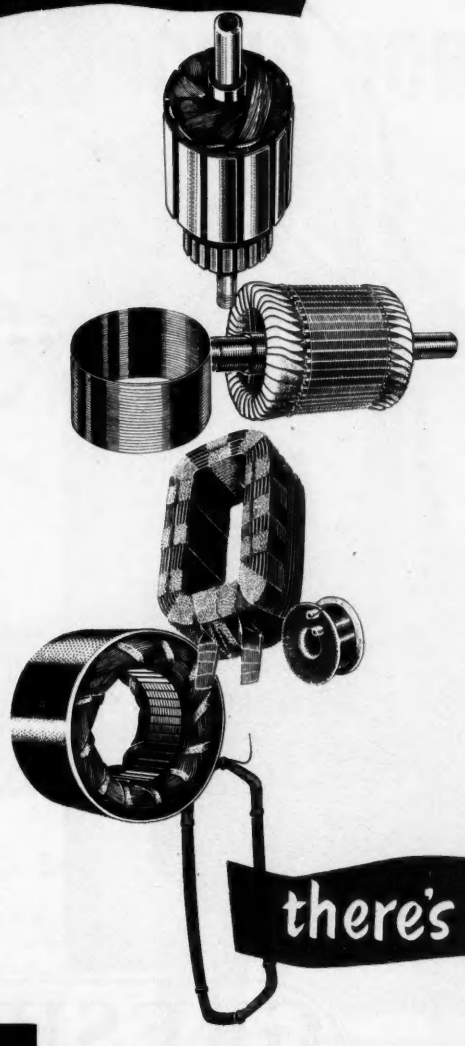

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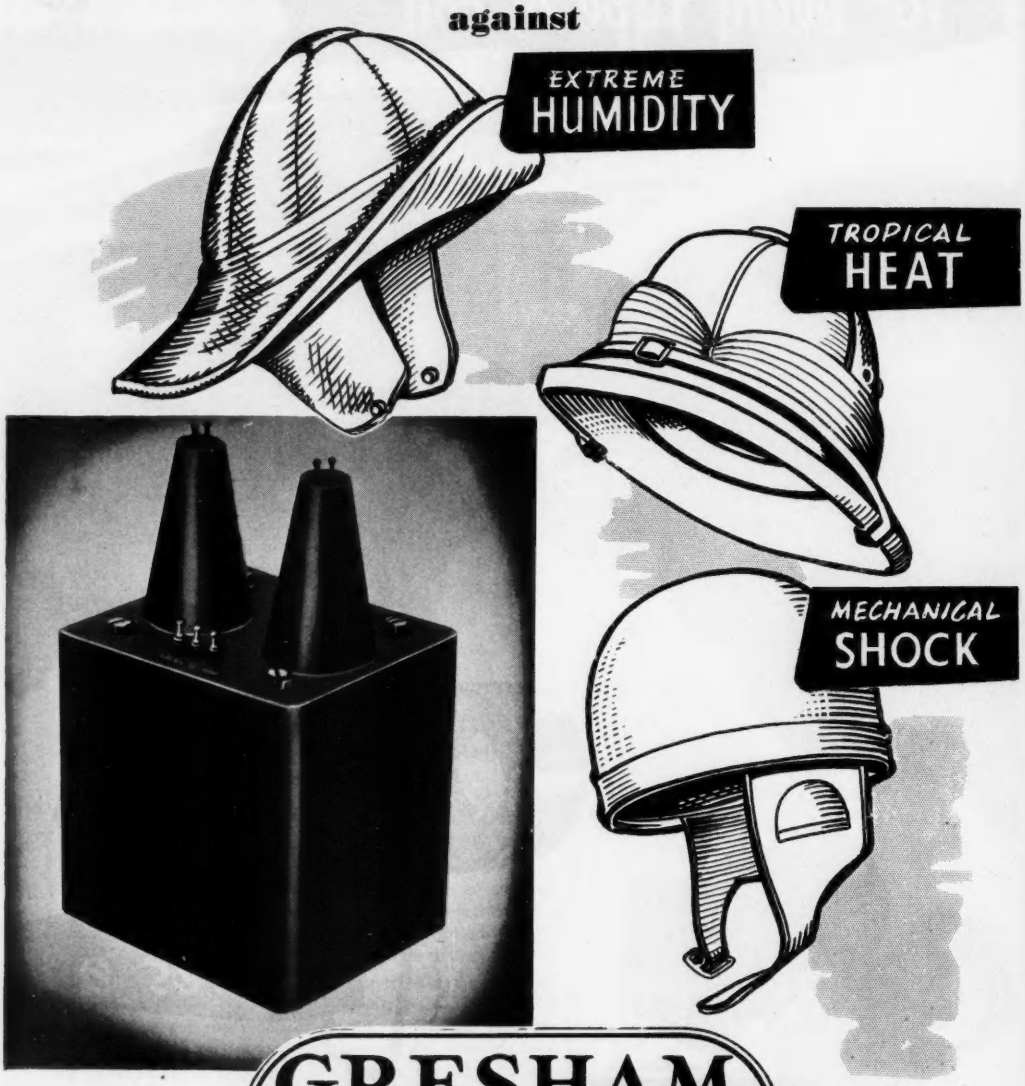

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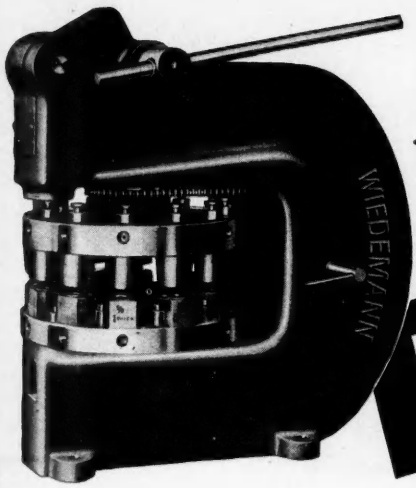

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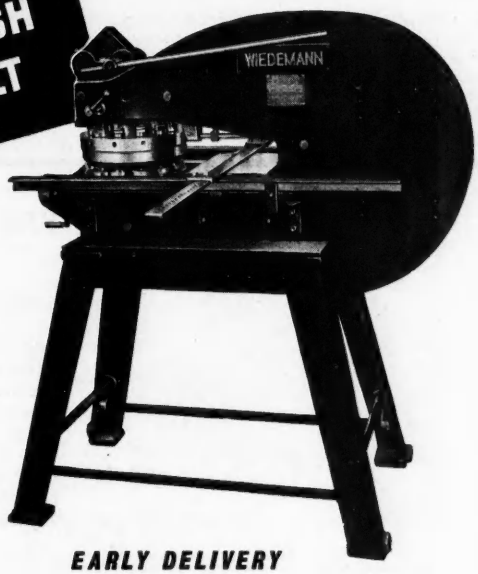

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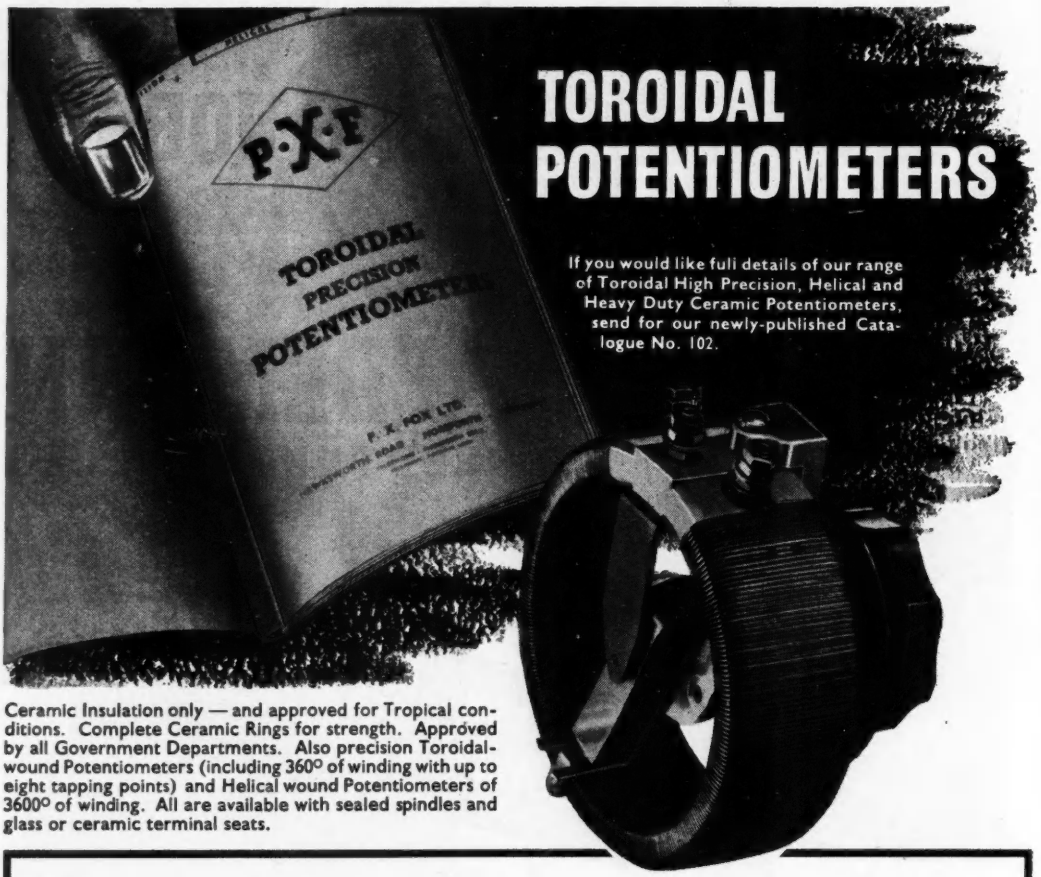

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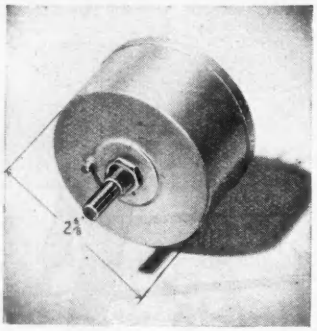

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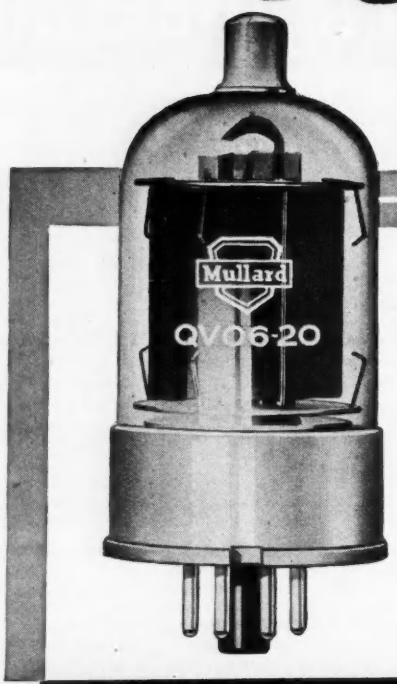

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V_{g1} max.	−180	V
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Class "C" Telegraphy and F.M. Telephony	600 320	52 25	60 175
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Class "AB1"	600	82	A.F.
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MVT160

ELECTRONIC ENGINEERING

VOL. XXVI No. 319

SEPTEMBER 1954

Commentary

THE past month has been one of considerable "boardroom" activity. The Atomic Energy Authority has taken over the responsibility for atomic energy research and development and the Independent Television Authority has been formed.

The former event, while of considerable interest since the atomic energy establishments are the centres of some of the most interesting electronic research and development, is not likely to have any great significance in the near future; it is more in the nature of a regrouping of forces than a major change, and the programme of research and development is not likely to be disrupted or modified to any great extent.

The passing of the Television Bill, which received the Royal Assent on 30 July, and the setting up of the Independent Television Authority is of more immediate concern. To quote the *Financial Times*: "So ends a dispute which has been going on for the best part of two years, in the course of which probably more irrelevancies have been uttered than on almost any other issue in modern times." This is, unfortunately, only too true and, as the bill now stands, it is fairly certain that the I.T.A. is assured of a hard and possibly hazardous life. The constitution of the Authority has been announced in the national Press and, at this stage, it can only be said that the members are a "mixed bag" of persons highly competent in their own spheres. How well they will adapt themselves to their new task time alone will tell; that they have little knowledge or experience of television is inevitable, but this should prove of little consequence, providing they are wise in their choice of advisers and senior employees.

From the more technical viewpoint it is impossible to make any comment at the moment as there is, as yet, no indication of what form commercial television will take; whether the transmissions will be over a national network, or be of more local interest and be over a number of regional networks.

Whatever one's feelings towards sponsored programmes, the argument is now over and it can only be hoped that this new venture will provide a sufficient revenue to develop and exploit television more adequately than the BBC has been able to do with its strictly limited finances.

* * *

The National Radio Show takes place at Earl's Court from 25 August to 4 September, and it is likely that this year's event will have a greater appeal to the general public than any of recent years. There is certain to be a great deal of interest in television receivers capable of reception in the higher frequency bands where the I.T.A. will operate and in radio receivers suitable for reception of the proposed F.M. transmissions. Technical interest will be provided by observing the methods by which the various manufacturers have solved the many problems presented by these two new fields. There will also be a large number of servicemen interested in test equipment for these higher frequencies, which points to a problem which is, perhaps, not given quite as much attention as it deserves.

Modern domestic radio and television equipment is becoming more and more complex. It is indeed a far cry from the three-valver of twenty years or so ago to a modern television receiver. The fault-finding and repair techniques and test equipment are equally far removed; the days of the wet finger technique are well behind. The introduction of Band III and IV television, V.H.F., F.M. and, possibly in the not very distant future, colour television will throw a considerable burden upon the technical knowledge of the serviceman and will also involve considerable expenditure on test gear. True, it will result in an increase in trade, but it will also present a difficult problem especially to the smaller business.

A great deal of attention and publicity has, in recent times, been given to the training and education of engineers and technologists, but this has mostly been concerned with those at graduate level. If all this complex new equipment is to be maintained in a manner that is a credit to the industry, a similar effort must be directed towards the training of servicemen; the qualified service engineer should be given a more widely recognized status and the set manufacturers should make a more rigorous effort to ensure that their appointed agents are staffed by qualified persons.

It is well, too, to remember that in time of war or national emergency it is the civilian servicemen who will form the hard core of the Service wireless and radar maintenance sections.

The set designer, too, has his part to play by keeping the servicing aspect well in mind during the design stages. In the case of the more complex equipment there is probably much to be said for the more widespread use of sub-assemblies which can be easily replaced by factory reconditioned units.

The Design and Construction of the Manchester University Digital Computor

By K. Lonsdale*

The basic principles of operation of the Manchester University Computor are outlined, although it has been necessary to omit some of the more involved facilities of the actual machine. An explanation is given of the binary system of numbers and the reasons for its use. The method of working of the more important parts of the machine such as the memory units are explained as is the type of electronic circuits employed in the machine.

THE construction of this computor, using storage units of the type developed by Professor F. C. Williams and his associates at Manchester University, was started during the summer of 1949 and the machine was completed and brought into operation at Manchester University in July, 1951.

A computor is basically a high speed adding machine, capable of performing arithmetic operations at very high speed. Using a human operator, it would be difficult to take advantage of this high speed because, inevitably, the vast majority of time spent on a problem would be that which the human operator requires to make his decisions. The main problem in constructing a fully automatic computor becomes the design of suitable circuits to control the arithmetical operations in the manner prescribed by the mathematician, but at a speed which takes full advantage of the speed of the calculating circuits. A medium has to be found which will hold the necessary instructions, and is capable of issuing such instructions at the rate at which the machine operates. In the case of the Manchester machine this is achieved by means of electrostatic storage registers. There are several storage registers of this type in the machine. The main storage consists of eight cathode-ray tubes, each capable of storing 1 280 binary digits arranged in 64 lines of 20 binary digits each. Each of these lines may be considered as a number of 20 digits length or approximately capable of representing a number of a magnitude of 10 to the sixth. Alternatively, a 20 digit location on a store may represent an instruction the machine is to obey. To ensure that instructions and numbers are handled in the correct manner and sequence, as dictated by the mathematician, a further store is included called the control store, and thirdly, a store called the accumulator is needed to receive the sums after arithmetic functions have been performed. Fig. 1 shows the layout of a basic machine equipped with three storage elements, as just described. There are more facilities in the complete computor, but this article will be restricted to this limited computor.

Before describing the method of operation of this machine, let us divert briefly to explain the binary system of numbers and the reason for its adoption in digital computors. As the purpose is to achieve high calculating speeds, electronics is the obvious medium to use. The only means to impart information must hence be via electronic circuits, capable of assuming more than one stable state. While it is possible to design electronic circuits with ten stable states, thus making a decimal computor possible, it is much easier to design reliable electronic circuits with only two stable states, thus causing the designer to make digital computors on a binary scale. The binary system itself is simple to understand, as it is in direct analogy with the decimal system. A decimal number is divided into its digital components by assigning the appropriate number to its units, tens, hundreds, and so on. For instance, the number 987 has seven units, eight tens and nine hundreds. We may note that it has seven times 10^0 plus 8 times 10^1 plus 9 times 10^2. Similarly, a binary number 1101 has 1 times 2^0 plus 0 times 2^1 plus 1 times 2^2 plus 1 times 2^3, which is 1 plus 4 plus 8 = 13.

Returning now to our simple machine, first assume that by some means the necessary instructions and numbers have been inserted in the main storage register. In general, the numbers will be in one part of this register and the instructions in another, and arranged in the sequence in which they are used. What is required to be done is to select the first of the instructions out of the main store register, to examine it and to interpret its meaning, which will be something like "take the number in storage location X and add it to the number in the accumulator." Readers must understand that instead of "add" such an order may include any of the other functions which are associated with the accumulator store. To read such an instruction, to interpret it and then to perform the operation asked for, is done sequentially in a number of beats. Each beat lasts one number or instruction length of 20 digits, called a "word" and is also the time occupied by the X time-base sweep on all storage tubes. As the basic repetition frequency of the machine is 100kc/s, and each digit of 10 microseconds length, each beat takes 200 microseconds plus 40 microseconds "black-out time," the latter being needed in between words to allow time-bases on the cathode-ray tubes to switch to the next line required.

If a word denotes a number then the machine will interpret it as a 20 digit binary number with the least significant digit occurring in the first 10 microseconds of the beat and of ascending binary significance towards the end of the beat. If it is an instruction then the 20 digits which are available are divided up to act on suitable selection circuits which determine line and tube selection and function to be obeyed. The first 5 digits determine the line, the next 4 the tube and the last 6 the function. The remaining 4 digits in the middle are used for a special facility which is outside the scope of the elemental machine under discussion.

Reverting to the sample instruction which asks the machine to take the number in storage location X and to add this to the contents of the accumulator. In the store, in this case on the first line on the first tube because a problem is just commencing—is this instruction. In the first 10 digits of the instruction is defined the address of the number which we wish to take to the accumulator and in the last 6 digits is the binary code which operates the circuit to perform the required function, the adder. The machine approaches the problem of performing a complete operation in two steps. The first step is

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to extract the next instruction to be obeyed from the main store, the second step is to use the information contained in this instruction to control the functions of the machine, and then to perform the operation thus specified. Each of these two steps is performed in two beats. A complete machine operation hence consists of four beats and is called a "bar" of operation. The actual mechanism of storage is explained later in this article, but for the present purpose it can be stated that during any beat it is possible to extract information contained in the particular line scanned by the X time-base.

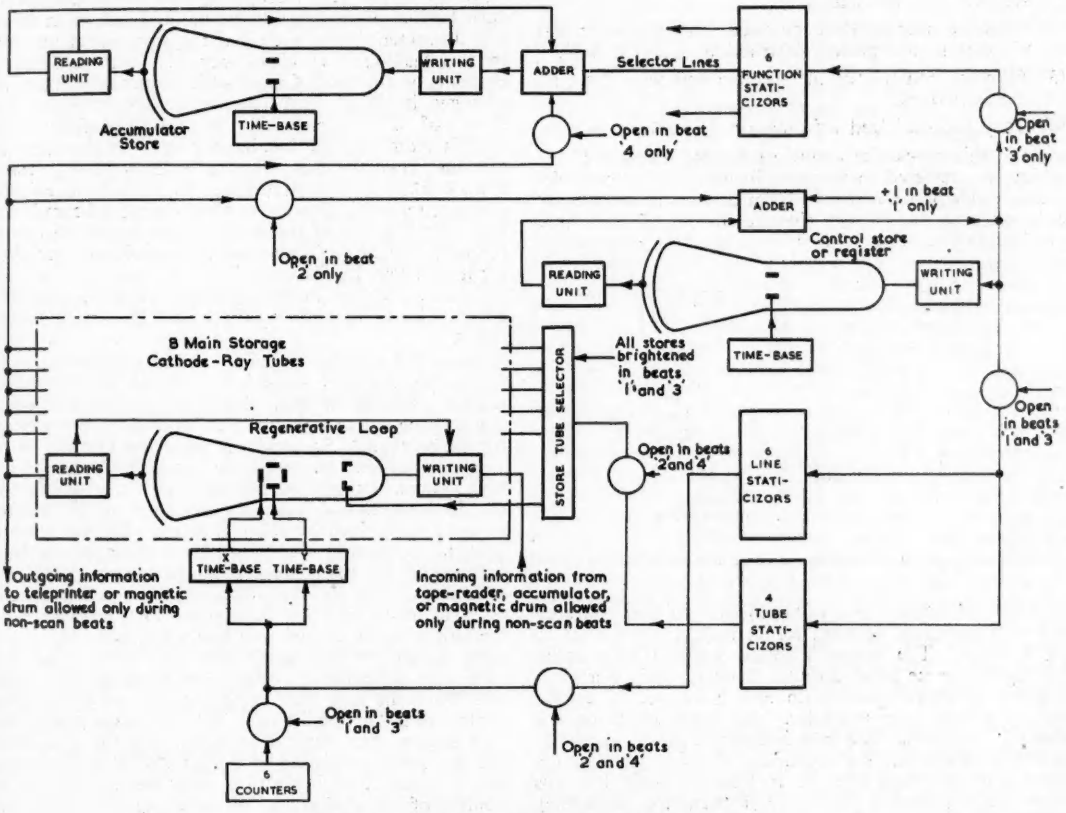

READING UNIT
WRITING UNIT
ADDER
Selector Lines
6 FUNCTION STATICIZORS
Accumulator Store
TIME-BASE
Open in beat '4' only
Open in beat '3' only
+1 in beat '1' only
Open in beat '2' only
Control store or register
8 Main Storage Cathode-Ray Tubes
All stores brightened in beats '1' and '3'
STORE TUBE SELECTOR
Regenerative Loop
Open in beats '2' and '4'
6 LINE STATICIZORS
Open in beats '1' and '3'
X TIME-BASE
Y TIME-BASE
Outgoing information to teleprinter or magnetic drum allowed only during non-scan beats
Incoming information from tape-reader, accumulator, or magnetic drum allowed only during non-scan beats
4 TUBE STATICIZORS
6 COUNTERS

Fig. 1. Basic machine equipped with three storage elements

Conversely it is possible to insert other information. The two actions are completely analogous to reading information from, or writing information into the store.

The actual line is selected by the Y time-base and a tube selector circuit which achieves selection by applying a negative voltage to the grids of non-selected cathode-ray tubes. Both the above circuits have to exert their selective influence for the duration of a whole beat at a time; but as previously explained they have to be controlled by the first 10 digits of an instruction which exists only as a pulse train. The need arises to convert the information contained in such a pulse train into static form; this is done by the "staticizors."

A staticizor is a flip-flop which is normally reset into one of its stable states and is triggered into its opposite state if a pulse is applied to its input terminal. There are 20 such staticizors, one to each digit position in a word. Suitable gates are incorporated at the input terminal to each staticizor so that a trigger is only passed on if a "1" is present in the appropriate digit position on the controlling instruction pulse train. The staticizors are thus divided in the same manner as an instruction, i.e., the first 6 are line staticizors, the next 4 are tube staticizors and the last 6 are function staticizors. It is this chain of staticizors which controls the Y time-base, the tube selector circuits and the selection of the function to be performed. It will be appreciated that it requires the full duration of a word to set this chain of staticizors and that neither they nor the circuits controlled by them can attain the configuration of the controlling instruction until the end of such an instruction beat. They are, however, ready to take complete control of the machine in the beat following the instruction beat.

It has been shown how an instruction pulse train which is applied to the staticizors during one beat may control the machine in the succeeding beat and stipulated that all instructions are assembled sequentially in the main store in the order in which they are required to be obeyed, i.e., the first instruction is on line 1 on store 0, the next on line 2, etc. The part of the machine used to control the extraction of these instructions from the store is the control register which is a cathode-ray tube store capable of storing two 20 digit lines. The first of these contains the address of the last instruction to be obeyed. In the example this would be zero. In the first beat a "1" is added to this (current instruction) line, and the resulting number is routed to the line and tube staticizors. In beat "2" the staticizors will control the selection circuits, i.e., line 1 on store 0 will be illuminated and the contents of this line read off into the other (present instruction) line on the control register. This is the first instruction and is routed

to the staticizors in beat "3." In beat "4" the staticizors control the required operation. This completes the first bar. Unless the function part of the just completed instruction contained the "stop code," the machine will automatically initiate the next bar. A "1" will be added to the current instruction line resulting in the extraction of the second instruction from the main store. This action will continue until the machine encounters a stop instruction signifying the completion of the particular problem. The 4 beats are thus defined as follows:

(1) Add 1 to current instruction line (C.I. line) and set line and tube staticizors.

(2) Take the number thus indicated from the store and place it in the present instruction line (P.I. line).

(3) Take the contents of the P.I. line and with it set all the staticizors.

(4) Obey the staticized information.

Earlier in this article the main fast storage medium of the machine was referred to as being in the form of cathode-ray tubes. These are a special form of tube manufactured for the purpose and to very close tolerances. The manner in which such a tube is used as a store is as follows:

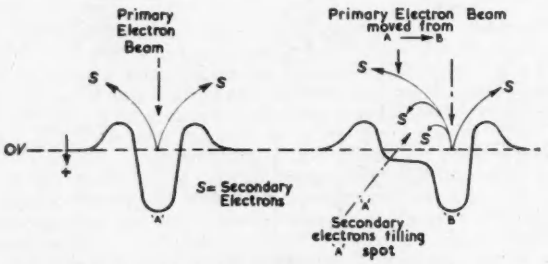


Fig. 2. Action of electrons on screen of storage tube

The tube is mounted in a conventional manner and supplied with deflexion voltages on its plate system so as to scan a raster. The screen is totally covered by a metal plate, spaced some small distance from it. This is a pick-up plate, insulated from earth and is connected to the input of a high gain amplifier. The store works on the following principles. The tube is operated at an accelerating voltage such that the secondary emission ratio of the screen is greater than one. If an electron beam hits this screen more electrons will leave it than are impingeing on it via the beam and the potential distribution will be as shown. (Fig. 2). It will "dig" a "well". If the beam is removed then this well will proceed to fill in slowly, but if the beam should return within less than about 1/5 second then the potential distribution will be substantially unchanged. If we now, instead of keeping the beam on this one spot, move it away slowly, then the well will travel from A to B filling in behind it as it goes along. Therefore, by considering the screen of the cathode-ray tube to have a lot of A spots which are regularly looked at by means of a system of deflexion potentials applied to the plates, the beam can be arranged to encounter a well or a filled spot totally dependent upon whether a small A-B deflexion was applied to the spot the last time the scanning occurred. Looking now at the output of the pick-up plate amplifier, this will be found to show regular waveforms which are dependent upon what is happening on the screen. If the scanning spot is looking at a well on the screen then the output becomes negative. If, however, it looks at a filled spot then the output becomes positive All that remains to be done to make the system regenerative is to arrange for a discriminating circuit in such a manner that if the positive signal appears on scanning an A spot then the spot is drawn out to B leaving a filled spot for the next scan, which repeats the process and so on. In this way it is possible to keep a particular pattern of charges on the screen of a store. The operation is purely a sequential one, as the beam of the cathode-ray tube is directed only at one spot at a time. The output of the amplifier will denote the presence or absence of a well and arrangements are made to leave that particular spot in the state in which it was found before the beam is caused to move to the next spot. The total time occupied in searching a spot and rewriting is 7μsec—the beam is then caused to move on to the next storage digit in the following 3μsec, during which time it has to be blacked out so as to avoid any unwanted filling during the period of its movement. In this fashion it is found possible to store 1 280 digit elements on the face of a 6in cathode-ray tube, these being arranged in 64 20 digit lines, which are arranged in two blocks of 32 lines each side by side. The order of scanning is from the top left-hand corner to the end of the first line, then the line below it, and so through the left-hand column and then through the right-hand column in a similar manner. During the time when the beam is travelling from the end of the previous line to the beginning of the next, the beam is blacked out and 40μsec are allowed for it to cover the distance. The total time needed to scan a "raster" of 64 lines is 10μsec per digit plus 40μsec between lines—a total of 240μsec per line or 12·8msec per raster.

From the description of the basic machine it remains to explain just how a particular line in the main store is selected, bearing in mind that it is necessary to fulfil all the time the storage condition of leaving no spot unscanned for longer than 1/5 second, or rather less in order to retain a safety margin. As stated the machine works on a four beat system. During the first beat all the machine does is to add 1 to control, therefore the main stores are free to be scanned for regeneration purposes. During the second beat the instruction is obtained from the store and the line scanned in the main store must be under control of the staticizors. During the third beat the contents of the P.I. line in control are transferred to the staticizors and the stores again unused and hence available for regeneration. Lastly, in the fourth beat the store is again used to extract the number required en route to the accumulator. Thus the four beat system is split up into 2 "scan" beats and 2 "action" beats. The time-base is so arranged that during scan beats it is under control of a separate counter chain consisting of 6 flip-flops called the regeneration counters. During action beats the time-base is under control of the staticizors. In operation the scan counters receive a trigger pulse during every action period, that is, in between the times they are going to be in control of the time-bases. This means that after every action period when any line in the store may be selected, the scan period select the line which is next to the one previously scanned. As the machine proceeds in its computation every line in the main store is scanned and hence regenerated sequentially. Line 0 first, then line 1, then line 2, etc. As there are 8 main stores this procedure would require not 6 but 9 counters in the regeneration counter chain, and also as there must be 480 microseconds between the start of the scan on one line and the start of the scan on the next, it would take a total of just over 0·245 seconds to scan the whole store and information would be lost. To avoid this, all 8 stores are arranged to be scanned in parallel, that is, line 0 on all 8 stores first, and so on, which reduces the number of counters required to 6, and causes any one line in the main stores to be regenerated at 32 millisecond intervals. The stores are selected by controlling the grids of the cathode-ray tubes so that only the selected store has its screen illuminated. During action beats this selection is controlled by the tube staticizors and during scan beats all tubes are brightened.

The Magnetic Drum

The method of using the 8 main storage tubes to perform a computation has been explained. As the total digit capacity of these 8 stores is only 10 240, the information that could be contained in such a working space would be sufficient only for calculations extending over fractions of a minute. A method is hence needed for replenishing this information at a high speed and for this purpose the magnetic drum has been developed.

The magnetic drum is a copper cylinder some 12in in height and 10in in diameter, coated with a very pure nickel plating. It is mounted on ball bearings at either end and rotated about its vertical axis at some 2 000 rev/min in synchronism with the machine, that is, one revolution of the drum is timed so as to take the same interval as the continuous and sequential scanning of 2 stores, i.e., representing 128 lines of 240μsec duration each. The drum has associated with it 256 magnetic heads, each of which is arranged over 256 imaginary annular rings on the wheel spaced 1/32in apart and 12 thousands of an inch wide. In order to commit information to the wheel an alternating digit current is applied to the writing coil in the head in which in its turn magnetizes the nickel on the surface of the wheel in a corresponding manner. Conversely, a magnetized annular ring or track on the wheel will induce corresponding alternating voltages in a pick-up coil in the head. Any of the magnetic heads can be selected at will and caused to be connected to any of the 8 stores and achieve what is called a half transfer. That is, only one store full of information is put on a track capable of holding the contents of two stores, or conversely the information contained in half a track may be transferred into one store, the two modes of operation corresponding to a "write" transfer and a "read" transfer. Alternatively the contents of two consecutively numbered stores may be associated in transfers to and from a complete magnetic track.

The method used to get information into the computor is by means of a teleprinter tape. There are alternative ways, such as the use of cards and magnetic tape, but we are not at present using them.

The problem facing the engineer who designs input and output machinery is that it is at this juncture that the transition from mechanical to electronic speeds in handling has to be faced. Commonly used teleprinter equipment operates at a speed little over 6 characters per second, each character, of course, being represented by a location hole on the teleprinter tape and 5 hole positions associated with it. As a hole may be present or not, it can represent a binary digit, which gives a 5 digit binary number per character on the tape. Four such characters go to make up a 20 digit binary number or the contents of a store line. The reading of the information from the tape is done in a photo-electric reader. This consists of a tape feeding mechanism which advances the characters one at a time so as to align with a row of 5 holes in a base-plate over which the tape is passing, the 5 holes being drilled coincident with the hole positions of the tape. Underneath the base-plate are arranged 5 photocells, each illuminated via one hole only. The illumination is provided by an electric lamp over the tape. Light from this lamp can reach a photocell only if the corresponding hole in the paper tape has been punched out, unpunched holes prevent a signal from reaching the photocells. The ouput signals from the 5 photocells are D.C. potentials and remain stable for as long as the tape is stationary. These potentials are amplified and then applied to a serializing or dynamicizing circuit which transforms the information into a 5 digit pulse train. The stores in the meanwhile have been regenerating and waiting. As soon as the character is aligned over the photocells a signal from the reader initiates a bar of operations in the machine, during one of whose beats the dynamicized 5 digit pulse train from the reader is routed into the accumulator. To read the succeeding character, the reader is now stepped on and the machine relapses into its regenerative waiting period until a new signal from the reader signifies the alignment of the next character, which is then read off in the same manner as before. This regenerative configuration of the machine is, of course, necessary to retain information in the stores. In the absence of an actual operation being performed the mechanism of the computor is always arranged to relapse into a purely regenerative cycle in which all stores are scanned continuously over and over again. For each step of the reader the machine requires the requisite instruction. As many characters are required to make up a complete store full of information, a complete programme is required to assign each 5 digit number to its correct destination as it arrives. The photo-electric reader used is actually a special piece of equipment designed for the computor.

The normal teleprinter type tape reader operates by drawing the tape along by means of a small ratchet which engages in the alignment holes. The information holes are sensed by 5 small spring loaded plungers which are mechanically connected to contacts. A plunger, on encountering a hole in the tape, rises due to its spring pressure and makes the contact. In the present reader not only have these plungers been replaced by photo-electric cells and a light source, but the ratchet has been replaced by an electromagnetic system. The drive is applied to the tape by friction from a roller which itself is driven by a differential gear train. The gears in turn are continually driven by an electric motor. By applying electromagnetic brakes to the correct points in the gear train, the roller may be driven or rested at will. The control voltages required are derived from a sixth photocell situated under the location hole position of the tape. The two advantages of the system are that the gear train is always rotating and that inertia losses are small either in accelerating or decelerating the tape, a factor which makes high speeds possible. Secondly, as no ratchets tear the tape, its life is prolonged much beyond the normal life of teleprinter tape, a very important factor when a large and frequently used "tape library" is necessary to operate a machine economically. The reader is capable of reading 200 characters per second as against the 7 characters of its purely mechanical counterpart.

In the output mechanism a page-teleprinter and tape punch are utilized. The method of feeding these with the requisite information has to be done by a programme which causes the 5 digit inputs to this apparatus to be energized in the correct sequence. Again, as in the reader, the machine regenerates while the teleprinter or punch complete their mechanical cycles.

Electronic Circuit Design

As previously mentioned, owing to the fact that the computor operates in the binary scale, all valves are required to have only two recognizable states of operation. The two states most obvious to use are "fully conducting" on the one hand, and "fully non-conducting" on the other. By making the valve most commonly used a pentode, it is possible to choose an anode load such that the valve "bottoms" in its fully conducting condition. The valve types used are the Mullard EF50 and EF55 pentodes, and the EA50 diode. Taking as an illustration an EF50 (see Fig. 3) assuming a pulse train of amplitude greater than 10 volts, and with its most positive level at, or slightly above earth, the anode waveforms of such a valve would be of about 280 volts amplitude as the anode would bottom at or about 20 volts. A potential divider between this anode and the grid of the following cathode-follower, is such that the lowest negative pulse voltage becomes minus 60 volts or greater, while the diode ensures that the top level is at earth. The same pulse at the cathode of the

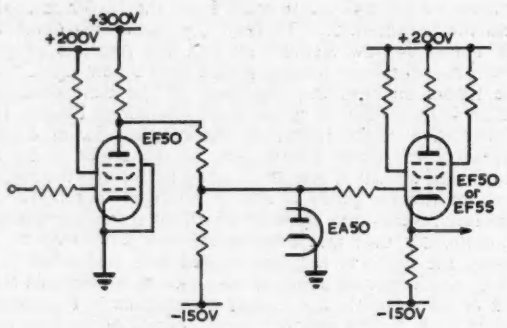
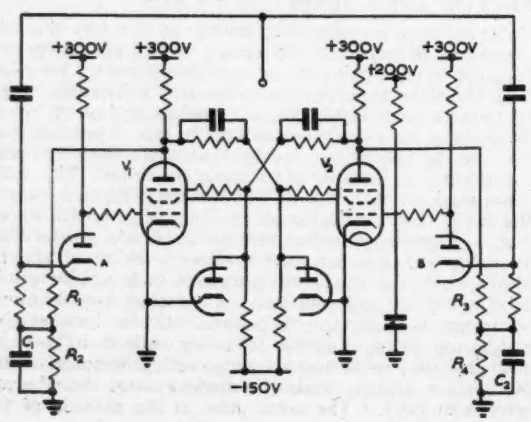


Fig. 3. Typical pentode on-off circuit

cathode-follower will have a voltage excursion positive to earth by the amount of the grid base of the cathode-follower under the current conditions determined by its cathode load. It is such an output pulse which is applied to input grids of pentodes in various diverse parts of the computor. The slightly positive excursion ensured by the cathode-follower is one of the safety measures taken to make quite sure of switching "on" any pentode which receives the pulse train. A negative excursion of 60 volts or thereabouts depends, of course, on the value of the potential divider, but it is possible to use standard 20 per cent tolerance calculations and still make sure that 60 volts or more negative excursions are achieved, yet that the pulse train on its positive swing crosses earth and enables the diode to clip it at earth. In practice, while calculations are made for 20 per cent resistors, 10 per cent resistors are used throughout. The 60 volt pulse generator is, of course, far bigger than is necessary to cut off either of the pentode types described above, but it is most useful when applied to the suppressor of an EF50 which has a suppressor base of about 55 to 60 volts. Where a pulse is to be applied to grids only, it has to be greater than 20 volts to give a safety margin, especially if one bears in mind that about 4 or 5 volts are positive to earth and hence of no use in cutting a valve off. In general these lower amplitude pulse trains have also the highest repetition frequencies. They are usually formed with an EF55 which has a lower anode load than the EF50 and whose anode is caught with a reverse diode at 50 volts. This results in a 30 volt pulse at the anode which after either D.C. restoration or potential dividing is fed into a cathode-follower grid, as before.

The flip-flop or staticizor circuit is an extension of the EF50 circuit shown. Two pentodes are used and the cross connexions are taken from the anode of one valve to the suppressor of the other, leaving the grids free for the application of trigger pulses. The same circuit in its counter version has a further resistance-capacitance network added to each anode, which ensures that only the grid of the conducting valve gets the negative trigger pulse. The action is as follows: Referring to Fig. 4, assume that V_1 is fully conducting and therefore V_2 is cut off. The anodes of both diodes A and B are at earth, owing to the dioding action of the valve grids. The cathode of diode A will be at about plus 5 volts, whereas the cathode of diode B will be at some plus 60 volts, owing to the action of the resistor chains R_1, R_2 and R_3 and R_4. It is clear that if a trigger pulse of amplitude greater than 5 volts, and less than 60 volts, is applied at the trigger terminal, then it will be transferred only on to the grid of valve V_1, which is what is required to put the circuit into its other stable state. The capacitors C_1 and C_2 are there to ensure a slow change of the masking voltage on the diode cathodes. The purpose of this rather elaborate seeming version of an already well-known circuit is its operation when several of these circuits are operated in cascade as a counter chain. In that case the waveform on the suppressor of V_2 would be cathode-followed and applied to the trigger terminal of the succeeding counter. Now, it is characteristic of unmasked counters that as the trigger is applied to both grids via differentiating circuits, the circuit begins its transition from one state to another until it attains an equilibrium state halfway in between. At that stage the deciding factor determining which way the counter will go, is entirely the different state of charge of the capacitors coupling the respective anodes to the opposite suppressors. The whole action, however, causes a short reversal of the anode motions of either valve at the equilibrium position, resulting in waveforms containing a small zigzag on each vertical edge. In a circuit designed for negative triggering, as the above, a negative edge would be contained in the waveform triggering the next counter, at a time when the changeover is actually positive going, and hence no counter trigger should be passed on. It is to avoid this undesirable state of affairs that the masked counter has been evolved.

Fig. 4. Flip-flop or staticizor circuit



Time-Bases

The 1 280 storage digits on each cathode-ray tube are grouped in 64 lines of 20 digits each. These lines are arranged in two columns of 32 lines side by side. The requirements of the X time-base are that the time-base potential must be stable during the time that a particular digit is inspected and re-written, as the case may be. It must then move on quickly to the next digit position and so on, until 20 digits at a time are scanned. The time-base waveform required to do this is the staircase-like waveform shown in Fig. 5(a). The circuit for achieving such a waveform is shown in Fig. 5(b). As will be readily recognized, this consists of a Miller integrator type time-base valve which has a cathode-follower to drive the feedback capacitor, the purpose of this cathode-follower being solely to achieve a faster flyback time. The run down is initiated by the return to earth of the suppressor of the Miller valve at the beginning of each 20 digit period and is completed at the end of this period by returning the suppressor to minus 60 volts. The waveform is the 40 microsecond blackout period, mentioned previously as being necessary to ensure correct working of the time-bases. The waveform which causes the time-base to pause in each of the digit positions is one of the basic waveforms called the dash waveform, this being at 100kc/s repetition frequency and its mark-space ratio being determined entirely by storage considerations. This waveform is applied to the diode, as shown on the diagram, causing diode 2 to open-circuit whenever the waveform goes nega-

tive. This causes the time-base to hesitate at whatever potential it happens to be because the Miller capacitor time-constant becomes infinite. As the dash waveform is fixed in time with respect to the blackout waveform, and as the Miller anode is accurately caught with a diode at its upper excursion, the resulting time-base will have the hesitating steps always at identical voltage levels and hence the same spots on the cathode-ray tube will be accurately illuminated. The remainder of the circuit shown consists of paraphase valves which again employ the principle of the cathode-follower driving the feedback circuit, in order to obtain a low output impedance.

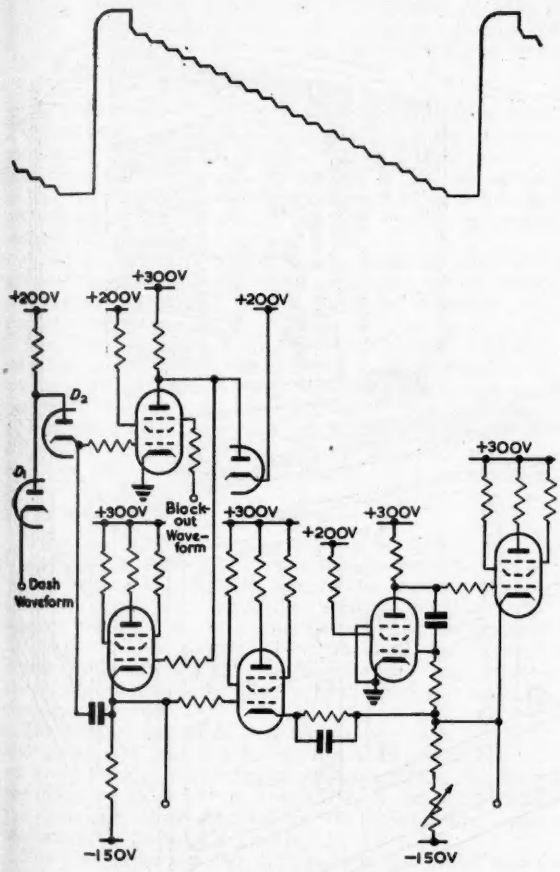


Fig. 5. Staircase waveform and generator

The Y time-base circuit has to be rather different as it must obey the staticizors at one time, and the regeneration counters at another. Moreover, a particular configuration of the staticizors must align the time-base on one particular line—Fig. 6 illustrates the principle used. As there are 32 lines to be selected, 5 separate channels are employed. In each channel a double pentode switch feeds a diode which is part of the time-base selector mechanism. The time-base itself is an anode-follower with the cathode-follower in the feedback loop, commonly called by us an "anode-cathode follower." To the grid are connected the anodes of 5 diodes to the cathodes of which are connected 5 resistors to a negative voltage. These resistors are graded in magnitude so as to draw currents from the grid in a binary ascending scale. That is, the largest of these resistors is made such that its inclusion or removal from the anode-follower moves the anode voltage by an amount equivalent to the space in between lines on the cathode-ray tube, or about 2 volts. The next resistor will be half the value of the largest and thus will cause a movement at the anode equivalent to 2 lines. The third resistor will cause an equivalent movement of 4 lines, and so on, so that the smallest resistor is equivalent to 16 lines. It now becomes obvious that by the application of negative or positive potentials to any of the companion diodes D_6 to D_{10}, any combination of resistors connected to the negative line may be incorporated in the anode-follower circuit, and thus any potential equivalent between the range of line 0 to line 31 may be obtained, this being equivalent to saying that any desired line on the cathode-ray tube may be selected for scanning at will. The double pentode switches, one of which is also shown, have their anodes connected to a common load, which means that either valve conducting will cause this potential to fall to some plus 20 volts and via the potential divider permit the companion diode to open-circuit and hence the relevant negative going resistor to become part of the time-base anode-follower. The suppressor of one of the switching pentodes is kept negative and the pentode put out of action during regeneration beats. On the grid of this pentode is applied the output of the staticizor which is associated in magnitude to the anode-follower resistor controlled by the particular switch. The other pentode has its suppressor kept negative during action periods and to its grid is applied the output of the regeneration counter of the same significance as the staticizor, for example, the smallest anode-follower leak controlling 16 lines at a time will be controlled by a

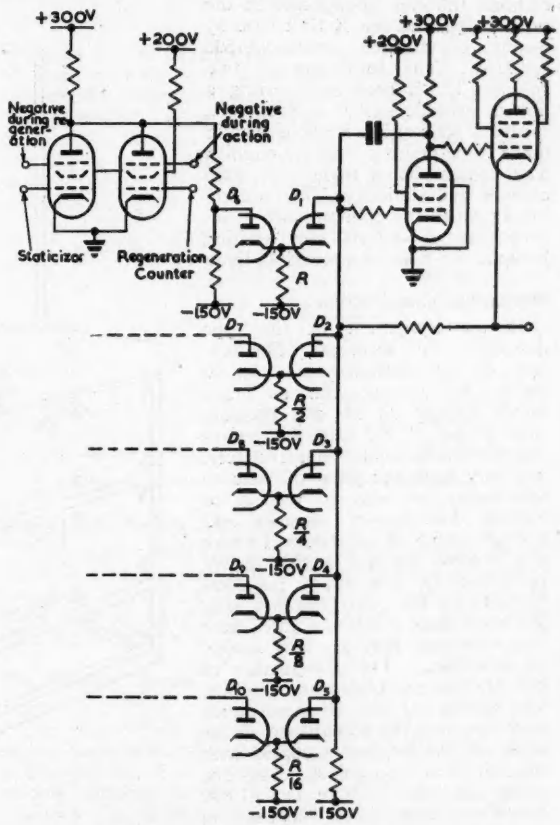


Fig. 6. Principle used for alignment of Y time-base

pentode switch which has staticizor 5 and counter 5 as its controlling waveforms. The action of the circuit is that during regeneration periods the regeneration counter controls the anode voltage of the switching pentodes, and hence the line selection, and during action periods the staticizors perform the same function on the identical circuit element, namely, the feedback resistor in the anode-follower. It is most important that the same line physically on the cathode-ray tube is illuminated to a very high accuracy, to achieve which would be impossible should it be attempted to use separate circuits for the two modes of operation. The output of the time-base anode-cathode follower, paraphased in the same manner as the X time-base by means of further anode-cathode followers. The formation of two columns is achieved by inserting a double pentode switch controlling a feedback resistor in a suitable point in the X time-phase paraphase circuits. The control being under the sixth counter and staticizor. This is commonly called the column shift waveform, as it affects the shifting between the two columns of 32 lines.

Mechanical Construction

In an equipment of the type described, the foremost consideration of the designer must be to design his circuits with as much safety margin as he can possibly provide for. He rates his valves and his components conservatively, not only from the point of view of tolerances, but also in respect of wattage loadings of resistors and voltage ratings of capacitors. To take this process logically a step nearer perfection, he also mounts his components so that they are not subjected to their maximum rated heat and also that they are not subject to vibration. The construction of the Manchester University machine was carried out with all those points very much in the foreground in the mind of the designer. Coupled with this, it was recognized that one could not hope to have some 1 800 pentodes and 2 200 diodes in operation without failures occurring, such failures having to be found with the utmost speed and repaired easily. The mechanical design illustrated in Fig. 7 was evolved. The open chassis construction, and the method in which the chassis are mounted on the doors, make for good accessibility when servicing. All components are completely surrounded by air and are kept cool by an air stream which enters at the base of the computor and is extracted at the top by a fan. The doors themselves are rigid castings to ensure freedom from vibrations, and are themselves mounted on sturdy frames. Pulse leads and power supplies are taken to the door by flexible leads which have been very carefully tested to ensure their reliability under repeated flexing. The method in which leads are taken from the doors to a junction with the horizontal ducts which run along the whole of the computor, is shown clearly in Fig. 7. The lower half of the frames has locations for cathode-ray tube stores and time-bases, as well as two small doors to house electronic circuits immediately associated with either, as the case may be. The mechanical size of these units is somewhat larger than that required for the upper structure of the framework, thus providing convenient ledges to run the horizontal ducts previously mentioned. The complete machine consists of 5 racks identical in construction to that shown, and a sixth rack which is slightly modified to contain the magnetic drum. The racks are bolted together end to end, and for convenience are arranged in two parallel bays of three racks each. High tension and other power supplies are routed along a busbar system at the top of the racks.

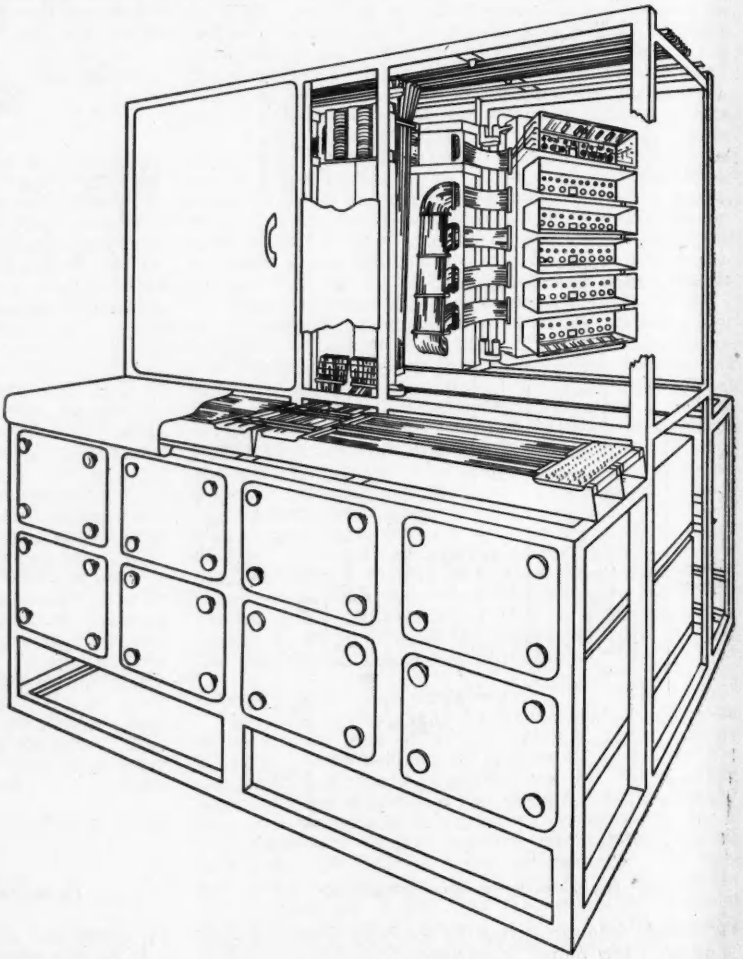


Fig. 7. One rack of the computor

Acknowledgments

The author wishes to acknowledge his indebtedness to Professor F. C. Williams and the computor research team at Manchester University, for advice and encouragement, and to members of the Ferranti Computor Department for their many contributions to the design of this machine and especially Mr. B. W. Pollard for his valuable advice.

He also wishes to thank Messrs. Ferranti Ltd., for permission to publish this article.

A General Purpose Monitor and Trigger

By P. Gleghorn, B.Sc.(Eng.)

A general purpose monitor, using uniselectors and relays is described. It is designed to give warning if less than a certain number of impulses (in this case 11) are received in a given time. The impulses are supplied by a trigger switch, in the present instance being operated by a patient's respiratory movements. If the monitor registers a predetermined drop in respiratory rate, a patient-cycled respirator (Donald and Lord[1]; Donald and Young[2]) can be automatically brought into action and is governed by the respirator control circuit which is included in this apparatus.

RECENT medical developments[1,2] have led to a type of artificial respiration in which instead of the patient's respiratory cycle being determined by an external agency, his attempts at respiration are used to trigger the action of the respirator. The augmented breathing rate is thus determined by the patient, a method which has many medical advantages.

A trigger switch is applied to the epigastric area and actuates the respirator control circuit, which by means of a solenoid controlled pressure system augments the patient's inspiratory effort.

The impulses from the trigger switch can also be fed into the monitor, and the number of these impulses is counted. If less than 11 are recorded in a monitoring period of 100 seconds, an alarm is sounded, indicating that the breathing rate has fallen below a safe level. A selector switch can be set so that the respirator solenoid does not commence operation until that alarm has sounded.

Safety Precautions and Refinements

If the respirator solenoid were energized directly by the trigger switch, there would be a danger that the patient would be unable to exhale, due to the pressure applied from the respirator; and this pressure could not be released until the solenoid was de-energized by opening the trigger switch contact. Thus, to avoid the patient's breath being artificially held, the solenoid must be de-energized automatically after a predetermined time, in this case $\frac{1}{2}$ second.

The patient's breathing may require very little assisting, and it may be undesirable for the solenoid to operate on every closing of the trigger switch contact. To cater for this, a paralysis circuit is included, by means of which the operation of the solenoid can be inhibited for a preset time after assisting a breath.

The above two facilities are the most important under this heading, but a number of other minor facilities have also been included. A buzzer will sound a warning if the contacts of the trigger switch remain closed (due to the patient holding his breath, or to the switch sticking) for more than 10 seconds. A switch is also provided so that the alarm bell on the monitor can ring for 5 seconds, after which the next monitoring period commences automatically, or can ring continuously until manually reset.

In addition to the selector switch setting mentioned in the basic requirements, other settings are available to select the operation of the monitor or the respirator mechanism singly, or both together.

The monitor and respirator control system is shown in block form in Fig. 1 and the monitor and control circuit in Fig. 2.

Timing

The H.T. supply to the valves is provided by a half-wave rectifier with resistance-capacitance smoothing. The timing valves each have a relay in the anode circuit, and the cathode of each is returned to a point on a fixed potential divider (R_4 and R_5 or R_7 and R_8). This provides the bias when the valve is cut off. A large capacitance is connected between grid and cathode. The principle of the timing mechanism is to charge and/or discharge this capacitance through a resistance, causing the valve to conduct or be cut off in a time determined by the time-constant of the charging resistance and the grid-cathode capacitance.

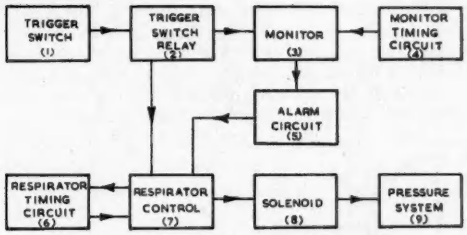


Fig. 1. Diagram of monitor and respirator control

The Trigger Switch

The trigger switch (S_7) is placed in series with relay C, which is supplied with half-wave rectified heater voltage, smoothed by a 32μF capacitor. Contact C_2 causes the trigger switch indicator lamp (L_2) to light in synchronism with the switch.

The Monitor Circuit

TIMING

The monitor consists of two uniselectors, one of which counts the number of attempted respirations, and the other is stepped round at 5 second intervals to time the 100 second sampling period, which obtains when 2U is on positions 2 to 21 inclusive; breath counting is done during this sampling period. The 5 second cycle starts with V_{1a} cut off by a negative potential on its grid, and F_1 open. C_3 discharges through R_3, and after 5 seconds the valve is conducting sufficient current to pick up relay B. This operates relay F and $DM2$ via B_1, assuming S_{3a} is on position 2, 3 or 4. F_1 on closing cuts off the valve, hence releasing relay F and $DM2$ whose wipers then move on one step. It is necessary to have relay F to avoid a very precise contact adjustment which would otherwise be necessary if F_1 were placed on relay B.

On positions 22 to 24 inclusive of 2U, a circuit is completed to $DM2$ via its interruptor contacts, which thus drives it to position 25. By extending the number of positions in which this circuit is completed to $DM2$, a flexible method of reducing the sampling period is provided.

COUNTING

During the sampling period, the counting uniselector 1U will step on once for each closing of C_1. No further counts above 25 can be recorded since the 25th position

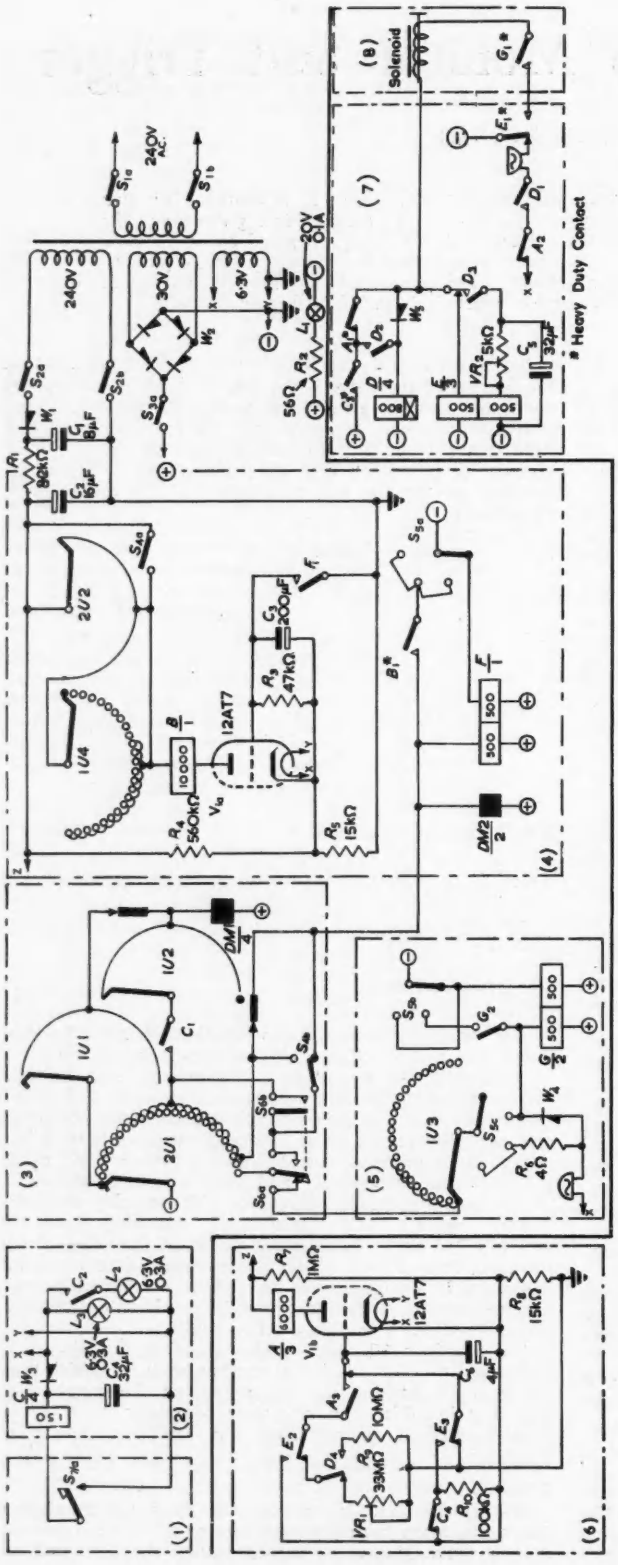


Fig. 2. Monitor and respirator control circuit

on $1U2$ is blank. This prevents false counts due to the wipers commencing a second cycle.

MONITORING

At the end of the sampling period the timing uniselector $2U$ checks the number of counts recorded. On position 25 of $2U$, a circuit is completed (if less than 11 counts have been recorded) from the heater transformer via the alarm bell and $1U3$ to the earthed negative supply on the wiper of $2U1$. If 11 or more counts have been recorded, $1U3$ will break this circuit.

When $2U$ moves to position 1 after 5 seconds, $1U$ will be homed via $1U1$, and the 100 second cycle is completed.

SPECIAL FACILITIES—ALARM RESET SWITCH (S_4)

Normally the alarm bell will ring for only 5 seconds, after which the next sampling period will commence automatically; this is with S_{4a} closed ("auto" position). If, however, S_{4a} is open ("manual" position), the supply to V_{1a} is taken through uniselector banks $2U2$ and $1U4$, which will cut off the supply. This will prevent further movement of $2U$.

The bell will thus continue to ring until the reset button S_6 is pressed, which will energize $DM2$. On releasing S_6, $2U$ will step on one position, and hence home $1U$ in the normal way.

SPECIAL FACILITIES—MONITOR RESET

Before using the monitor, both uniselectors should be on position 1. Pressing S_6 with S_{4b} closed will home $2U$ which will in turn home $1U$.

Respirator Control Circuit: Description of Cycle

OPERATION OF THE SOLENOID

On closing the trigger switch, relay C operates. C_3 passes current to energize relay E, and relay D via W_5. Relay D then locks on via D_2 to the supply from C_3, and also transfers the supply to relay E on to the hold-on coil, which is in series with VR_2. This is adjusted to pass sufficient current to allow the relay to remain energized, but insufficient to allow it to pick up again after it has been de-energized. Relay D is made slow to operate to prevent D_3 (make before break) breaking the circuit to the pick-up coil of relay E before it has had time to energize.

Assuming that G_1 is closed, the solenoid operating the pressure system will also be energized.

THE AUTOMATIC RELEASE

With E_3 closed, capacitor C_6 will discharge through R_{10}. After about $\frac{1}{2}$ second, V_{1b} will conduct sufficiently to pick up relay A, which opens A_1 and de-energizes the solenoid. If S_7 opens during this $\frac{1}{2}$ second, R_{10} is shorted out by C_4 and relay A picks up immediately. Because of capacitor C_5, relay E is slow to release, and hence the opening of C_3 will not cause E_3 to open before relay A has picked up.

A_1 opening will also de-energize relay E, but because this is slow to release, the grid of V_{1b} will be connected directly to the cathode for a short time via A_3 (make before break) and E_3. This ensures that capacitor C_6 is fully discharged before starting the next part of the timing cycle.

PARALYSIS TIMING

S_7 will normally open shortly after the solenoid is de-energized as the patient exhales, hence causing relay D to de-energize. Capacitor C_6 is now charged through VR_1, which is the "Set Paralysis" control. The time taken before relay A drops off can be varied up to 3 seconds. During this period, the solenoid cannot be energized by C_3 closing since A_1 will be open. On dropping off, relay A applies the full negative bias to the grid of V_{1b}, and the circuit is ready for the next triggering of relay C.

THE 10 SECOND ALARM

If, however, S_7 does not open, due either to breath holding or to the switch sticking, relay D will remain energized, and capacitor C_3 will charge through R_9, relay A now taking 10 seconds before dropping off. A_1 on closing cannot pick up relay E, owing to VR_2 being in series with the coil. Hence a circuit will be completed through the buzzer in a manner similar to that through the bell via A_2, D_1 and E_1. S_7 opening will cause D_1 to open and hence restore the circuit to normal.

The Selector Switch (S_5)

SETTINGS

Position 1—Respirator mechanism alone.

2—Monitor alone, bringing respirator mechanism into operation in addition after the alarm bell has rung.

3—Monitor and respirator mechanism together.

4—Monitor alone.

The selection of the respirator mechanism entails the closing of G_1 to allow the solenoid to operate. Thus on positions 1 and 3 a circuit is completed to relay G via S_{5b}.

Selection of the monitor entails providing a supply to allow B_1 to operate $DM2$; this is done via positions 2, 3 and 4 of S_{5a}. The fact that $1U$ may still be stepped by C_1 when the selector switch is on position 1 is immaterial—it will not operate after recording 25 breaths. To prevent V_{1a} being fully conducting when the selector switch is on position 1, S_{5a} is arranged to pick up relay F, thus holding the valve cut off.

AUTOMATIC CUTTING IN (S_5 on position 2)

On position 25, the completion of the circuit via $1U3$ in addition to ringing the alarm bell picks up relay G, which then locks over G_2. R_6 is included to provide a resistance in the bell circuit equal to that of W_4; this rectifier is included to prevent relay G picking up through the heater winding. The two coils of relay G are connected in opposition, otherwise there is a chance of the relay remaining energized if S_{5b} is moved quickly from position 1 to 2.

Conclusion

This apparatus has been constructed and is now in service for Mr. Ian Donald at Hammersmith Hospital, who has also incorporated the mechanism in his servo respirator for premature infants[1]. In this instance, the photo-electric trigger mechanism of the respirator is used to operate the trigger relay C.

In certain applications it may be desirable to make R_{10} variable, thus placing the automatic release time under the control of the operator.

There are two distinct parts of the apparatus, the monitor and the respirator mechanism, as shown by the dividing line on the circuit diagram. It is thus possible to construct the monitor alone without the respirator mechanism.

Acknowledgment

The author wishes to express his thanks to Mr. Ian Donald for his co-operation in this work.

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2. DONALD, I., YOUNG, I. M. *J. Physiol*, *116*, 41p (1952)

Ultrasonic Cleaning Plant

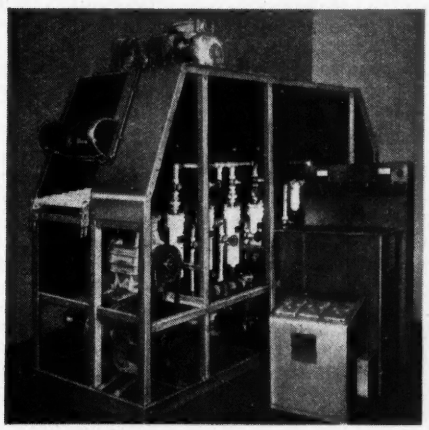
THIS plant, which is probably the first of its kind to be made in Europe, and believed to be the first completely automatic unit in the world, was made to the order of a well-known firm who require to clean small precision engineering parts to a degree not obtainable with conventional cleaning machinery. It was produced jointly by Ultrasonics Limited, and Mullard Limited, who were approached by the Board of Trade some months ago. The company who have ordered this plant wished to import a machine from the U.S.A., but they were referred to the above companies to see if a unit could be produced in this country.

As no information was available as to the type of plant produced in the U.S.A. this unit had to be designed and produced from scratch in two months due to urgency of the users requirements.

It has been established that if an article to which foreign particles, e.g., grease or other matter is adhering, is irradiated ultrasonically in a bath containing a suitable fluid, the part will be made chemically clean. The ultrasonic energy is able to reach those parts of the articles which are normally inaccessible, and foreign particles are rapidly dislodged. A suitable frequency and intensity are necessary depending on the nature of the material to be cleaned. In this particular plant the frequency is 1Mc/s and the maximum intensity at the transducers approximately 5W/cm², the generator output being 2½kW. The transducers in this case are barium titanate a ceramic crystal which has the advantage over quartz of needing only low voltages for excitation, and can therefore be operated in direct contact with the liquid.

The parts to be cleaned are placed in open wire mesh trays. These run into the plant on rollers and are automatically backed up on a conveyor which takes them through the two stage cleaning process. The cleaning fluid is recirculated through a magnetic filter in the first stage, and a combination of magnetic and ceramic filters in the second stage.

At the end of the conveyor system the trays are transferred to another roller conveyor on which they travel to the next stage in production. It is estimated that over one million parts will be cleaned daily in this machine. The variable speed drive on the conveyor allows considerable latitude so that the plant can be run at a speed to match the production rate of the preceding processes.



The ultrasonic cleaning plant

LEO

(Lyons Electronic Office)

(Part 3)

A Checking Device for Punched Data Tapes

By E. J. Kaye*, B.Sc.(Eng.), A.C.G.I., and G. R. Gibbs*

MANY of the electronic digital computors which are in use today employ punched paper tape as a means of input, and LEO (Lyons Electronic Office) is no exception. Being principally employed on clerical work, LEO has to deal with much larger quantities of input data than a calculator which is concerned with problems of a mathematical nature. For example, during a payroll programme for 10 000 persons no fewer than 160 000 rows of holes on punched tape have to be prepared by recording operators and read into the calculator. The recording operators or "recorders" as we shall now refer to them, typing 3½ characters per second on standard keyboard perforators are bound occasionally to make mistakes (in fact errors do occur at the rate of approximately 2 per 1 000 characters). It is of paramount importance that these errors are completely eliminated before presenting the data to the calculator.

The need for a foolproof tape checking device was foreseen at an early stage in the development and an investigation was carried out to determine the most efficient method of checking tapes. Fundamentally there are two approaches to the problem of checking; these have been described by Alexander[15] as the parallel method and the cascade method. In the parallel method, two tapes are produced by different recorders and automatically compared by two tape readers and a check circuit. In the cascade method[16], the second operator or "checker" produces the final tape, the initial tape providing a character by character check on the checker's transcription. The first method was discarded in favour of the second after experimental trial. The parallel method is wasteful of personnel, apparatus and time; it requires two operators to produce the tapes and when the check circuit shows up an error, a third operator has still to produce the final tape. Only two stages of operation are required in the cascade method and where much data has to be prepared the saving of time is considerable.

Logical Requirements of the System

In the cascade system, the recorder, working from the original manuscript, uses a standard keyboard perforator to prepare the first tape. This tape is arranged to have a blank section at the beginning and the data is perforated in blocks of numbers. Each digit of a number is represented by a row of holes on the tape, the blocks being separated by sections of blank tape. If the recorder is aware she has made an error she is permitted to correct it by back-spacing the tape and obliterating the incorrect character by overpunching it with a "cancel" character. For obvious reasons this is chosen to be the "all holes" character.

This tape is handed with the original manuscript to the checker, who loads the tape on to the tape reader of the checking device. Working from the same manuscript the checker types on the keyboard of a teleprinter fitted with a perforating attachment, thus producing a new tape. Each character that she records must be compared with the corresponding character on the first tape. Thus the tape reader must step to the next row of holes on the tape each time any of the teleprinter keys is depressed. The reader must automatically step past any "cancel" character on the original tape.

Sections of blank tape are never required to be checked, and therefore it is also desirable that the reader should automatically step past blank tape. This would mean, however, that there would be no sections of blank tape on the final tape. Consequently the checker is provided with a key enabling her to "run-out" any number of spaces from the keyboard at any point on the tape without stepping the reader or activating the comparison circuits. The initial tape is loaded on to the reader at any point on the first section of the blank tape. After the first teleprinter key is depressed, the tape automatically runs through the reader and comes to rest on the first character which is not blank tape or "all holes."

The checker might easily lose her place in the manuscript and must therefore be provided with a means of knowing which character she last recorded. A register of five lamps is provided for this purpose which displays the binary code of the character last sent from the keyboard.

Provided that agreement is found between keyboard and reader characters the checker is permitted to continue. As soon as a disagreement is noted, the system must automatically "lock-out." When this occurs, the keyboard of the teleprinter is rendered inoperative, a red "error" lamp lights and no further action can take place.

The operator must first decide whether the disagreement is a result of her own error ("Checker's error") or whether it is due to an error on the first tape ("Recorder's error"). This she can do by examining the five keyboard register lights. If it is her own error she must back space her tape which must render the keyboard operative in order to permit her to "cancel" the wrong character (in the same way as the recorder, i.e., by pressing the "cancel" key on the keyboard) and to insert the correct character from the keyboard. She must not, however, be permitted to continue before she has checked that the character inserted is really the correct character and consequently her keyboard is once again rendered inoperative. She is provided with an AGREEMENT CHECK button which she must press at this point before she can continue. If she has corrected the error, the error light goes out and her keyboard is reconnected. If she has made a second mistake the error light remains on and she must back-space again and repeat the "checker's error" correction routine.

If she finds that the error is not her own, she must then confirm that it is a recorder's error, by examining the tape on the reader. For this reason, the tape guide on the top of the reader is made of transparent material, so that she can read the tape without removing it from the reader.

Recorder's errors can only be of three types:—

(1) One or more wrong characters may have been per-

* *J. Lyons & Company Ltd.*

forated by the recorder instead of the same number of correct characters.

(2) The recorder may have omitted a character or group of characters.

(3) The recorder may have inserted an extra character or group of characters.

The correction procedure is different in the three cases. If there is a single wrong digit on the original tape, the checker presses a WRONG CHARACTER switch which causes the wrong digit to be ignored. (This is permissible as the correct character has already been perforated by the checker on her tape). The error light goes out and she can proceed normally.

If digits have been omitted she presses the CHARACTERS OMITTED switch. This reconnects her keyboard and she can then insert the remainder of the missing digits and the succeeding digit from the keyboard. She must again check for agreement before she is permitted to continue.

Where extra characters have been inserted on the original tape she presses a CHARACTERS INSERTED switch. This permits her to advance the original tape past the inserted digits, one row of holes at a time, by means of a STEP READER button until the next correct character is reached. Once again she must check for agreement before she is allowed to proceed.

It is essential to have some way of ensuring that the

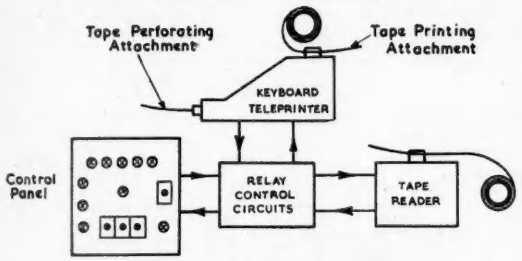


Fig. 18. The tape checking device

checker has made the corrections properly. In order to do this a printed proof tape is produced which gives a complete record of the checker's action. A checker's error is indicated by a black asterisk following the incorrect character. Recorder's errors are indicated in red. A single red asterisk indicates a single wrong character corrected. Characters omitted by the recorder appear in red. Two or more red asterisks indicate that unwanted characters have been deleted by the checker. The first asterisk indicates a recorder's error and the remainder give the number of characters deleted. A scrutineer can thus quickly check all the corrections, once again referring to the original manuscript, to ensure that they have been made correctly.

Brief Description of Apparatus

Fig. 18 shows a simple block schematic of the four pieces of equipment which form the tape checking device. The keyboard teleprinter, which is fitted with a standard perforating attachment and a tape carriage, has had several non-standard modifications made to it. A set of contacts has been fitted to the coding bars so that the character can be transmitted to the checking circuits and the keyboard register lamps. It is, of course, appreciated that comparison carried out from these contacts will not take account of punching errors due to maladjustment of the perforating attachment. Ideally, a reading station immediately following the punches is required, but this is not a practical proposition. A special solenoid has been fitted to the teleprinter to immobilize the keyboard clutch for rendering the keyboard inoperative and another to shift the ribbon, to give the two-colour printing on the proof tape. Contacts have been fitted to the back-space button and the "cancel" key (15) on the keyboard.

The reader is electro-mechanical and is of a type originally developed by the Mathematical Laboratory, Cambridge for use on EDSAC. The reader has five peckers which sense the holes in the tape in parallel, and is fitted with two solenoids, one for withdrawing the peckers and one for feeding the tape. The operation of the solenoids is fully interlocked by a relay circuit which need not be described here, to prevent, for example, the movement of the tape before the peckers are withdrawn. If a 50 volt signal of short duration is sent to the reader it steps to the next row of holes.

The third item is a control panel (Fig. 19) fitted with keys, buttons and lamps. The five keyboard register lamps are fitted at the top of the panel. In the case of an error they indicate the last character typed before the system locked out. A green "ready" lamp indicates to the

Fig. 19. The control panel showing the keys, lamps and buttons required for correcting errors

operator that the keyboard has been rendered operable. Two red error lamps are fitted, the first giving a general error indication and the second a special indication during the checker's error correction sequence. The control panel also carries the other keys and buttons concerned with the correction of errors. The RUN-OUT key is also fitted to this panel.

The last item of equipment is a panel of 39 relays, which perform the logical operations required by the system.

The CANCEL key on the keyboard transmits to the teleprinter a signal in which all the information elements are "mark" elements. This "all mark" signal is arranged to print an asterisk; hence the black asterisk for checker's error. During the correction of recorder's errors (1) and (3), an artificial signal must be sent to the teleprinter so as to indicate on the proof sheet that the correction has been made. The most convenient signal to simulate in an external circuit is the "all mark" signal, which again prints an asterisk. In order to distinguish between asterisks relating to checker's and recorder's errors the ribbon is shifted and is not reset until after the next character has been sent from the keyboard. In this way the recorder's errors are indicated by red asterisks.

Operating Procedure

A highly simplified block schematic of the operating procedure is shown in Fig. 20. Each stage will be considered in more detail.

Normal Cycle of Operation (Fig. 21.)

The checker depresses one of the teleprinter keys and the character is perforated and stored in the teleprinter. The previous character is printed on the proof tape. The keyboard is temporarily immobilized while the reader steps to the next row of holes in order to allow the reader to step on if this character is either "all holes" or blank tape. When the reader comes to rest, the character on the reader is compared with the character sent from the keyboard. If they agree the keyboard is brought into action again and the cycle is recreated. If, however, the characters do not agree, the error condition is set up.

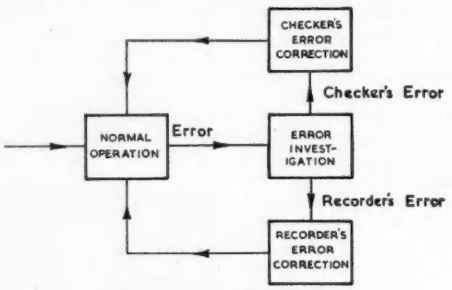


Fig. 20. Operating procedure

Error Investigation

The steps of the error investigation, as described in the logical requirements, are set out in Fig. 22. This investigation enables the checker to decide whether a checker's error or a recorder's error has been made.

Checker's Error Correction

The operating procedure for the correction of a checker's error is shown in Fig. 23. An interlock has been provided to ensure that the operator first presses the "cancel" key. If she depresses any other key instead, the keyboard is rendered inoperative and she is obliged to "back-space" the tape again. She is also prevented from inserting more than one character from the keyboard after the "cancel" character by a second interlock which also renders the keyboard inoperative. A third interlock prevents the agreement check being carried out if the Agreement

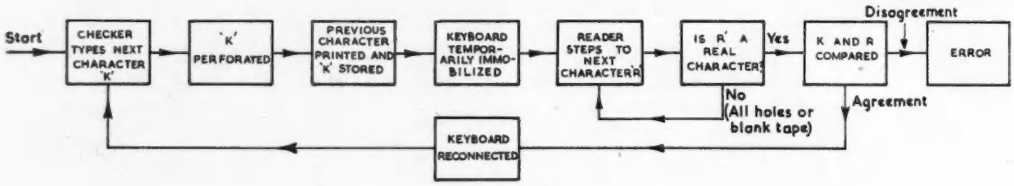


Fig. 21. Normal cycle

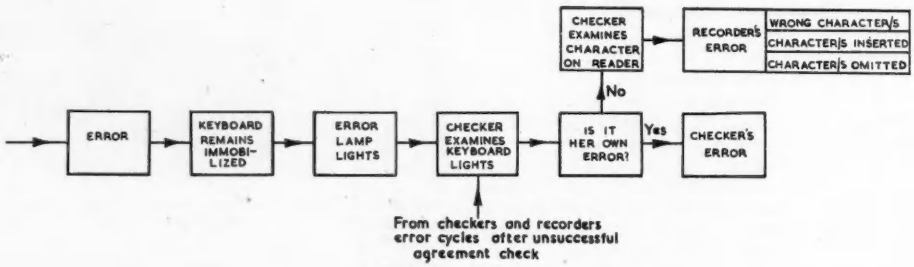
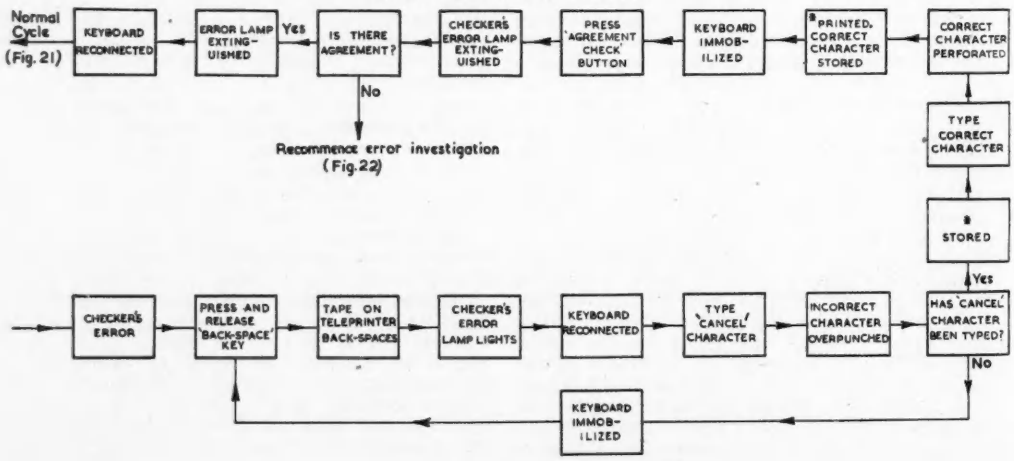


Fig. 22. Error investigation

Fig. 23. Checker's error correction



CHECK button is pressed too early in the sequence (e.g., after the "cancel" key has been pressed).

RECORDER'S ERROR CORRECTION

The correction routines for the three types of recorder's error are shown in Fig. 24, 25 and 26. The asterisks stored, during the WRONG CHARACTER correction and the CHARACTERS INSERTED correction, are the result of the artificial "all-mark" signal which is sent from the relay control circuits when the WRONG CHARACTER key, the CHARACTERS INSERTED key or the STEP READER button is pressed on the control panel.

Relay Circuits

The complete relay circuit is shown in Fig. 27. It consists of 14 P.O. Type 3 000 relays and 25 Siemens high-speed relays. The circuits operate as follows:—

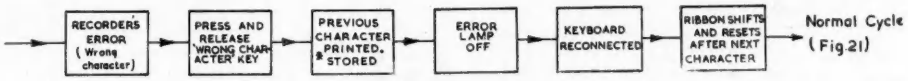

RECORDERS ERROR (Wrong character)
PRESS AND RELEASE 'WRONG CHARACTER' KEY
PREVIOUS CHARACTER PRINTED, * STORED
ERROR LAMP OFF
KEYBOARD RECONNECTED
RIBBON SHIFTS AND RESETS AFTER NEXT CHARACTER
Normal Cycle (Fig.21)

Fig. 24. Recorder's error correction (wrong character)

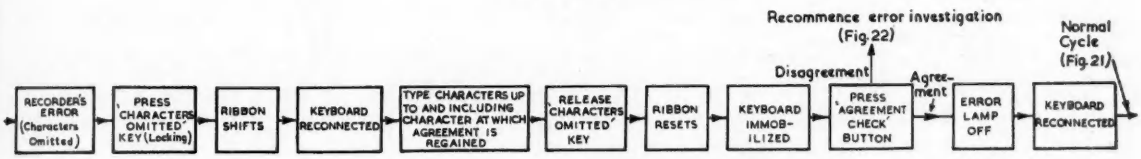


Fig. 25. Recorder's error correction (characters omitted)

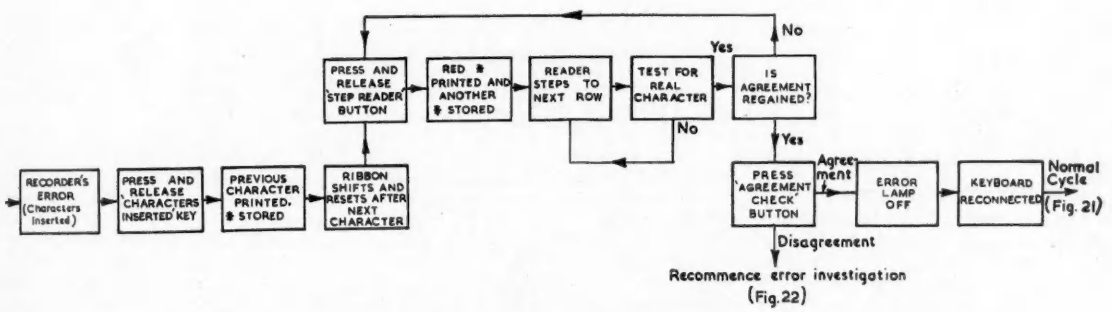


Fig. 26. Recorder's error correction (characters inserted)

SEQUENCE INITIATION

When any key is depressed on the teleprinter keyboard a contact inside the teleprinter known as the transmit-receive contact operates relays *TRA*, *TRB* and *TRC*, which relay the action of the transmit-receive contact to other parts of the circuit. The high speed relay *S* is also operated and in turn operates relays *CA* and *CB* which lock in via CA_1 thus removing the short-circuit from relay *R*. R_1 operates and short-circuits the coil of relay *S* which now releases. CB_2 operates the step reader relay *SR*.

READER STEP AND CHARACTER DETECTOR CIRCUITS

Relay *CB* in the sequence initiation circuit is used to step the reader. Contact CB_3 closes and provides an earth path for relay *B*. The contact of *B* sends 50 volts to the tape reader causing it to step. The circuits in the tape reader cause the contact F_1 to operate at the beginning of the reader cycle, so that when the contact SR_2 operates—as a result of the operation of *CB*—relay *B* releases. The contact F_1 makes again at the end of the cycle indicating that the reader has come to rest.

As previously explained it is necessary to make the tape reader step past the "all holes" character and blank tape. The circuit which recognizes a character other than these two is known as the character detector. The operation of the circuit is based on the fact that with any character other than "all holes" or blank tape, the state of at least two adjacent tape contacts will differ. The two coils of each of the four high-speed relays *CDA-CDD* are connected so that they oppose each other. If both coils are energized the relay does not operate, but if either of the coils is energized alone then the relay will operate. Thus if all the tape reader contacts are earthed ("all holes") then all the coils are energized and none of the relays operate. Similarly if all the tape contacts are open none of the relays operate. For any other state of the contacts at least one of the relays must operate. If therefore the code on the tape is either all holes or blank tape none of the contacts CDA_1-CDD_1 will have changed over, and at the end of the reader cycle the contact F_1 will apply an earth to relay *B* causing the tape reader to step. This process continues until a character other than "all holes" or "blank tape" appears on the tape. One of the contacts CDA_1-CDD_1 will then operate and the earth is presented to the comparison circuit contacts.

Leads are taken direct from the tape reader contacts to the comparison circuit.

KEYBOARD REGISTER

In order that intelligence may be transmitted from the teleprinter keyboard in a parallel form, a contact is fitted to each of the five coding bars of the teleprinter such that

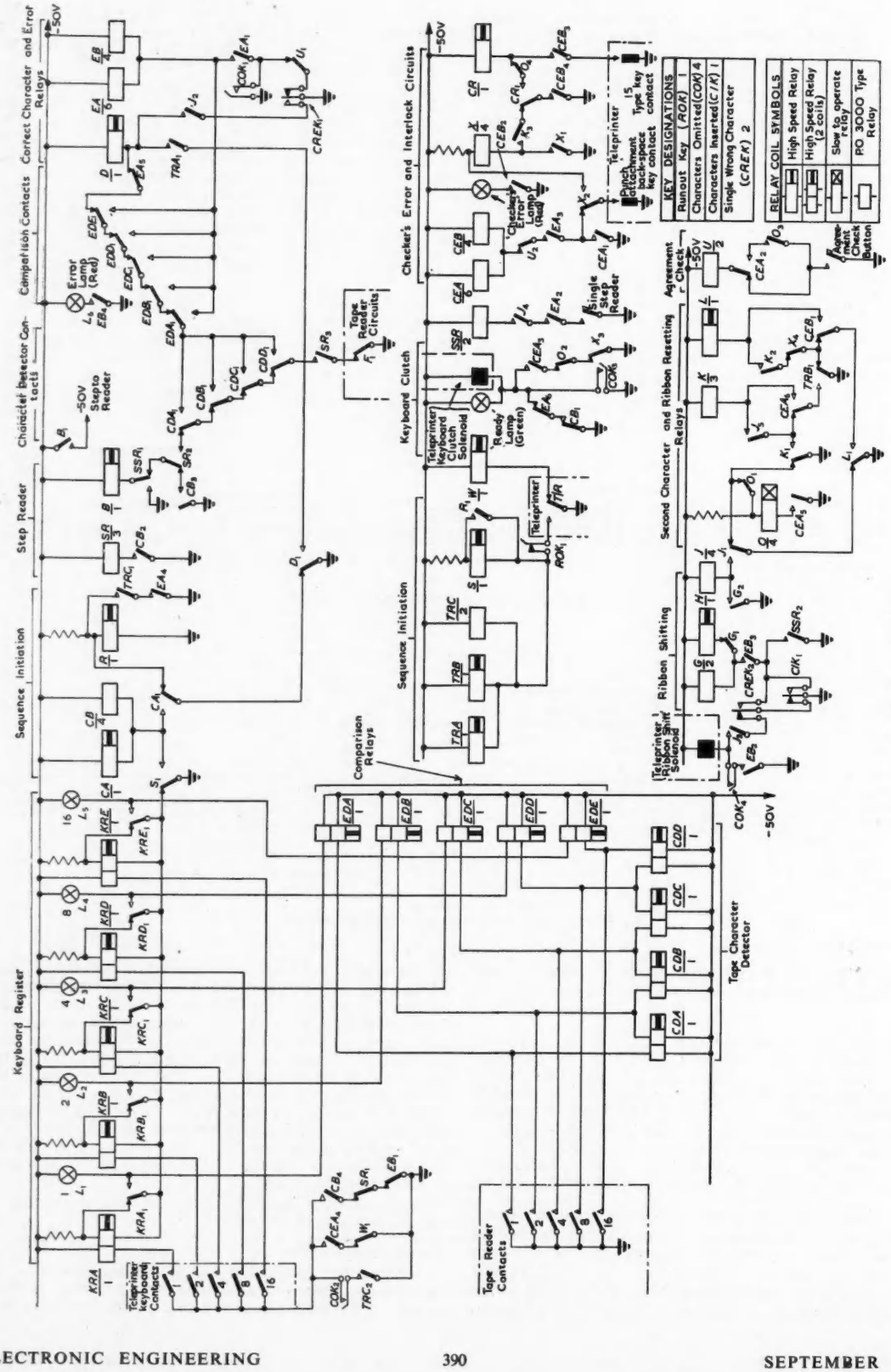


Fig. 27. The relay circuits

each key on the keyboard sets up the contacts in a binary code which represents the decimal numeral required. The circuit comprises five double wound high speed relays. One half of each coil is operated from one keyboard contact. The other half coil is connected to the normally made side of the relay contact so that this half winding is short-circuited and connected to earth via the contact S_1, the supply voltage being developed across the resistor. Now if an earth is applied to the first half coil the relay will be energized and the contacts will change over, removing the short-circuit from the second half coil, which is now energized via the resistor and serves to lock in the relay. The normally off contacts are connected to the five lamps mounted on the control box.

During normal operation the register is first reset by the operation of the contact S_1 as previously described. This removes the earth path for the relays which then release. After the register is reset, the serial operation of the contacts CB_4 and SR_1 present an earth path via the keyboard contacts for about 15 milliseconds, allowing the new code set up on the contacts to be transferred to the register.

Leads are also taken from the normally off side of the relay contacts, to the comparison circuit.

Comparison Circuit, Correct Character Circuits and Error Detector

The coils of the five relays *EDA* to *EDE* which form the comparison circuit are connected in opposition to each other as in the character detector, so that if the condition of any tape reader contact differs from that of the corresponding keyboard contact the comparison circuit relay concerned will operate.

If the settings of the keyboard register and tape reader contacts agree none of the contacts EDA_1-EDE_1 will operate and an earth path will be applied to relay *D* via the character detector contacts and the F_1 contact in the tape reader. Since the contact TRA_1 is made during the teleprinter cycle, relay *D* will lock in through its own contact to earth. The contact *D* having operated, removes the earth path for relays *CA* and *CB* and resets these relays. At the end of the teleprinter cycle the transmit-receive contacts reset to the receive side and the relay *TRA* is released. This in turn releases relay *D*, and its contact now completes the short-circuit across the coil of relay *R*; thus the short is removed from relay *S* and the sequence is complete.

If there is disagreement between the keyboard and the reader then at least one of the contacts EDA_1-EDE_1 will operate and apply an earth to the two error detector relays *EA* and *EB*. These two relays will lock in via EA_1, U_1 and the control box key *CREK*.

The operation of these two relays sets up the various error clearing circuits and completely immobilizes the keyboard.

Keyboard Clutch Circuit

As previously explained it is necessary to immobilize the keyboard while the comparison circuits operate. This means that all characters are treated as incorrect until shown to be correct. The reason for this is that the reader stepping time plus the comparison time is very nearly equal to the teleprinter cycle time. Thus since the error is not detected until a new character is about to be typed by the operator it is better and easier to immobilize the keyboard from the beginning of the cycle rather than trying to effect the immobilization in the very short time which actually exists between the recognition of an error and the completion of the teleprinter cycle. In practice the keyboard is immobilized by means of a solenoid latching mechanism attached to the keyboard clutch detent control shaft. The latch is normally engaged, preventing the operation of the clutch. When the solenoid is energized the latch is disengaged, allowing the clutch to operate.

The keyboard is immobilized by removing the earth path for the keyboard clutch solenoid just after the teleprinter cycle commences using the contact CB_1. If the character is correct then this contact remakes just after the end of the teleprinter cycle, causing at the worst only a slight impediment to a very fast operator. In practice long and continuous fast operation of the keyboard is required before this is experienced. The arrangement of the circuits prevents re-operation of the sequence initiation section until the previous operation is complete. If the comparison indicates an error, the error detector relays operate and break the contact EA_6, thus completely immobilizing the keyboard.

Checker's Error and Interlock Circuits

When the punch attachment back-space key is pressed, a contact on this key operates the relays *CEA* and *CEB* which then lock in via the contact CEA_1. The keyboard clutch solenoid is energized via CEA_3.

In order to ensure that the operator types neither more nor less than two characters the three relays, *K*, *L* and *O* are used. With the two relays *CEA* and *CEB* operated the contact TRB_1, which operates at the beginning of the teleprinter cycle, will operate relay *K* via contact CEA_6. When TRB_1 resets at the end of the cycle an earth is provided via the contact K_2 so that relay *L* operates and locks in via CEB_1 and its own contact L_1. At the beginning of the next teleprinter cycle the contact TRB_1 again operates relay *K*. This time when the contact K_1 operates there is no longer a short-circuit across the coil of relay *O* which operates and locks in. This relay, the "second character" relay, is arranged to operate slowly so that at the end of the first teleprinter cycle it is unaffected by the momentary removal of the short-circuit.

The operation of relay *O* removes the earth path from the keyboard clutch solenoid ensuring that no more than two characters can be typed. The operator now presses the Agreement Check button which operates relay *U*, and provided that the settings of the keyboard register and tape reader contacts now agree, the relays *EA* and *EB* will be released by the contact U_1 and allow relay *D* to operate via the contact EA_5, thus resetting the circuit as for a correct sequence. It can be seen that should the operator press the Agreement Check button after typing one character only, relay *U* will not operate because relay *O* will not yet have operated and the operator is forced to type one more character before agreement can be sought.

In order to ensure that the first character she types is in fact the "all holes" character (15) a contact is fitted to the "15" key of the teleprinter keyboard. This contact operates relay *CR* which then locks in via its own contact. It can be seen that if any key other than 15 is pressed in error then, since the relay *CR* does not operate, the contact K_3 causes relay *X* to operate. This immobilizes the keyboard clutch and changes over the back-space earth path so that to resume operation the operator must again back-space the tape. The back-space contact now releases *X* thus permitting the correction sequence to be recommenced.

Recorder's Error and Ribbon Shifting Circuits

The Wrong Character key operates the contact $CREK_1$ which removes the locking path for the relays *EA* and *EB*, and operates *D* through the contact J_2. The relays *CA*, *CB*, and in turn *SR* are released and the error condition is effectively cleared.

The printing of the asterisk is effected by the relays *G* and *H*. When the key is operated the contact $CREK_2$ provides an earth path via the contacts CIK_2 for the relays. Relay *H* is a high speed relay and has time to operate before the contact G_1 opens and removes its earth path. Thus the contact H_1 operates for about 15 milliseconds and sends what is effectively the start element of an "all

mark" signal to the teleprinter. This is arranged to select the asterisk character on the teleprinter typehead. Relay *G* also causes *J* to operate and lock in via the contacts J_1 and *L*.

Thus when the WRONG CHARACTER key is released an earth path is provided for the ribbon shift solenoid. This solenoid actuates the ribbon jumper so that the red portion of the two-colour ribbon is opposite the typehead. During the next cycle the asterisk is printed in red and at the end of the cycle the ribbon resets. This is achieved by contact TRB_1 which operates relay *K* during the cycle when the asterisk is printed. At the end of the cycle when the contact TRB_1 releases, relay *L* operates via K_2 and locks in through its own contact L_1. This releases relay *J* which resets the ribbon shift solenoid. Relay *K* and relay *L* are released in turn. The pressing of the CHARACTERS OMITTED key causes the contact COK_4 to operate the ribbon shift solenoid directly, thus preparing the teleprinter for printing in red. The contact COK_2 provides an earth path for the keyboard contacts while the contact COK_1 prevents the two relays *EA* and *EB* from being reset while the key is down.

When the AGREEMENT CHECK button is pressed the locking earth path for the two error relays *EA* and *EB* is removed and if there is now a correct comparison these relays reset. The contact EA_3 then allows relay *D* to operate which in turn releases the relays *CA*, *CB*, *R* and *SR*. Checking can now continue.

When the CHARACTERS INSERTED key is operated the contact COK_1 provides an earth path for relays, *G*, *H* and in turn *J* to operate as for the wrong character operation. This causes the "all mark" signal to be sent to the printer. When the key is released the ribbon shift solenoid operates. The STEP READER button now operates the relay *SSR*, operating both relay *B*, which steps the reader, and relays *G* and *H* to send the "all mark" signal to the printer. When the AGREEMENT CHECK button is pressed relay *D* operates if there is a correct comparison and resets the circuits as before. The ribbon is reset during the next teleprinter cycle as explained for the wrong character operation.

The RUN OUT key on the control box disconnects the transmit side of the teleprinter transmit-receive contacts from the sequence initiation relays by means of contact ROK_1 so that the checking circuits are not stimulated and the keyboard remains mobilized.

Fig. 28. General view of the tape checking device showing the teleprinter, tape reader and control panel

The operator sits at the teleprinter keyboard with the original manuscript on her left-hand side, and can swing round to examine the reader and make corrections using the control panel

Constructional Features

A photograph of the checking device is shown in Fig. 28. The tape reader and control box are on a separate small table at the side of the operator. The relay circuits are mounted on two panels housed in a dust-tight box, the box forming the back support for the teleprinter table. This can be seen in Fig. 29. The two panels are mounted on a hinged frame which opens to give access to the interconnexion wiring behind the panels.

Conclusions

With a design problem of this nature it is absolutely essential for the user to make a detailed study of the requirements, in order to discover at the outset the essential logical processes involved.

In the early stages of the study, the operating routine was changed many times in order to arrive at a system which would fully meet the requirements of the users and would result in the apparatus being easy for the checker to use. However, once the requirements had been clearly formulated the design of the relay circuits was straightforward. A prototype was constructed and after a few weeks' operational experience certain interlocks were added, (e.g. checkers' error correction) as a precaution should any ingenious attempt be made by the operator to circumvent the prescribed operating routine.

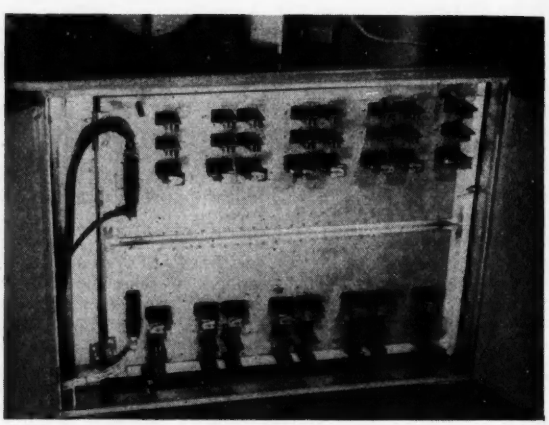


Fig. 29. Relay control circuits at the rear of the teleprinter table

The panel is hinged on the left-hand side and swings open to give access to the wiring behind

Our experience with the apparatus over a number of months has demonstrated that it is fully satisfactory for its purpose, provided the relays and mechanical parts are well maintained and special attention is given to the perforating attachment, for the reason mentioned previously. Four further instruments are in the process of construction.

Acknowledgments

The authors wish to acknowledge with thanks the many suggestions and criticisms made in discussion by their colleagues, and in particular the assistance given by Mr. A. T. Clements with the mechanical design and with the modifications to the teleprinter equipment.

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The Design of High Efficiency
Radio Frequency E.H.T. Supplies

By J. Barron*, M.A.

The basic problems involved in the design of radio frequency E.H.T. *supplies are discussed. The practical difficulties and the difficulties of theoretical design associated with air-cored step-up transformers for the production of high voltages are pointed out. It is shown that the use of a ferromagnetic core eliminates many of the difficulties, and alleviates others. A simple procedure for for the design of* E.H.T. *supplies is presented.*

RADIO frequency E.H.T. units are now widely used for several reasons. By working at high frequencies the size and weight of an E.H.T. transformer may be greatly reduced compared with those of a power frequency transformer of the same ratings. Owing to the use of high frequencies, the capacitance of the reservoir and smoothing capacitors may be reduced considerably. A further advantage is that the high frequency supply is usually non-lethal, because of the low stored energy, and because of the fact that an accidental overload quenches the power oscillator. Where normal H.T. and heater supplies are already available, as often is the case, radio frequency E.H.T. units become economical to construct for voltages in excess of about 1kV.

Air-Cored Transformers

Requirements

It will be helpful briefly to discuss the design and properties of air-cored transformers, so that the inherent theoretical and practical difficulties may be understood. An excellent paper by Schade[1] gives an analysis of the tuned step-up transformer as applied to radio frequency high voltage supplies. The essential requirements of the transformer are shown to be that it should have high unloaded Q factors for both primary and secondary windings, that the secondary coil should have as high a resonant impedance as possible, and that the coupling between windings should be as tight as possible.

Considering the secondary winding alone it is obvious that the power loss on no load for a given generated voltage will be a minimum when the resonant impedance is a maximum. The power loss due to the load current will be least when the secondary loaded Q is a maximum. In practice the second loss is usually small compared with the first. The primary loss is obviously least for a maximum primary unloaded Q. The maximum step-up ratio in the transformer is secured when the coupling is critical, but this condition is useless in practice for two reasons. With critical coupling the maximum power transfer to the secondary is half the input power so that the efficiency of the transformer cannot exceed 50 per cent. Secondly, the critical coupling coefficient depends upon the secondary Q, and therefore upon the load resistance, so that the step-up ratio varies with the load, and voltage regulation is poor. To obtain higher efficiency and better regulation the coupling should be as as high as possible, and much greater than the critical value. The critical value for the loaded transformer is made smaller by increasing the loaded Q of both primary and secondary. A further requirement is that, for satisfactory oscillator operation, the loaded Q as seen from the primary terminals should not be much less than 10 for a single ended oscillator, or 5 for a push-pull oscillator[2].

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Practical Difficulties

To deal now with practical considerations, the anode coil may be given a high Q factor by wavewinding with Litz, and normally does not cause any difficulty. The secondary coil is more troublesome, because of the large number of turns, and because of insulation requirements. The secondary is usually wavewound in thin spaced sections, but may be pile wound upon a suitably slotted former. Either process as normally carried out renders the coil rather expensive. The design of the transformer must commence with the secondary coil, which usually must be designed empirically, since calculations of self-capacitance are extremely difficult and approximate. A given secondary coil is suitable for use with only a limited range of load resistances, since the load must be low compared with the secondary resonant impedance, and at least 5 or 10 times the inductive reactance of the secondary at resonance, to ensure satisfactory oscillator operation and high efficiency.

A further problem arises concerning insulation. A particular coil will possess a limiting output voltage, beyond which it will break down electrically. When this voltage is reached, it is necessary either to increase the pie spacing, or to add further pies, in order to obtain higher output voltage. This rapidly becomes unprofitable, since the added pies do not couple tightly to those already present, and further, in order to retain a maximum Q factor, the coil diameter should be increased in proportion to its length. These problems set a limit to the Q value, and the resonant impedance of the coil which can be obtained economically.

The limitations are shown by the fact that the average commercial unit has an overall anode efficiency of about 20 per cent and assuming that the valve efficiency is about 60 per cent, this means that the transformer efficiency is limited to approximately 45 per cent, allowing for the rectifier heater power also supplied by the oscillator. Such supplies usually work at frequencies in the 100kc/s region, so that it is not possible to avoid rectifier heater supplies by the use of metal rectifiers.

A further difficulty caused by insulation requirements is that of obtaining tight coupling between the anode and E.H.T. windings. The limit obtainable in practice is about 20 per cent coupling. In designing a transformer for a particular output voltage the maximum coupling must be found experimentally, and, of course, the number of turns on the anode coil will depend upon the coupling obtained, so that the design process is complicated.

Finally, in order to eliminate parasitic oscillations, and to prevent jumps in oscillation frequency from one to the other of the peaks in the secondary resonance curve it is essential that the grid and anode windings be at opposite ends of the E.H.T. coil. This in turn leads to further insulation problems, and causes the induced grid voltage of the oscillator to become proportional to the secondary current instead of to the anode voltage swing. This may cause regulation troubles.

Ferro-magnetic Cored Transformers

Many of the above difficulties can be eliminated if a ferro-magnetic cored transformer is used, provided that additional power loss is not introduced by the core. The use of laminated cores is obviously uneconomical, and dust cores would not yield a great improvement. By the use of a core of Ferroxcube, however, significant improvements can be made. The method of design and construction to be described has been developed in the Cavendish Laboratory during the past three years, and several different units have given trouble free service over this period.

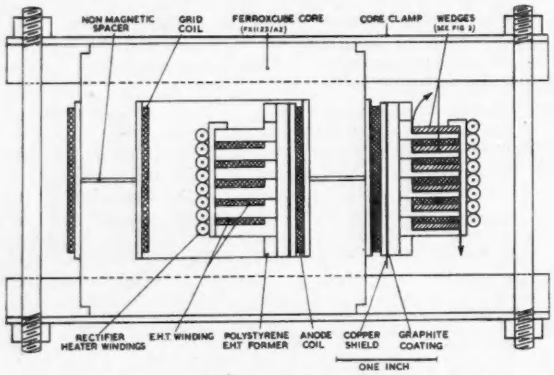

Fig. 1. Sectional drawing of complete transformer

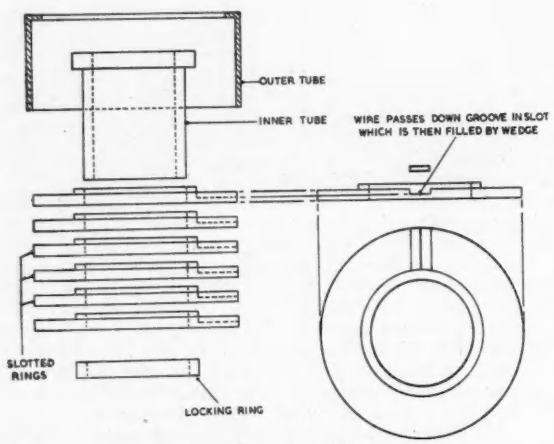

Fig. 2. Construction of the E.H.T. coil former

The main advantage in the use of a ferro-magnetic core is that the coupling may be taken as 100 per cent, so that voltage ratios are determined solely by turns ratios, and the design becomes that of a normal power transformer. The regulation obtained is practically that of the power oscillator alone, and the design of the E.H.T. coils is standardized. This leads to very convenient methods of design of units for varied applications.

Fig. 1. shows a drawing in section of a complete transformer, and Fig. 2. gives details of the construction of the E.H.T. coil former. It will be seen that the E.H.T. coil is pile wound in five sections in the slots of the former, which is moulded in polystyrene, and is placed outside the oscillator anode coil upon one limb of the core. It has been found in practice that the self-capacitance of a coil wound in this way is not much greater than that obtainable by wavewinding in pies, and the winding of the coil is far simpler in this form. The inside of the E.H.T. former is coated with graphite, and makes contact with a grounded copper screen between the former and the anode coil. This arrangement was adopted in order to prevent charges from building up on the inside of the former and possibly causing corona and sparking in the air space between the former and the anode coil. The oscillator grid coil is placed upon the second limb of the core. Rectifier heater windings, and any other heater windings which may be required, are wound on the outside of the E.H.T. former. According to insulation requirements, either P.V.C. covered wire, or polythene insulated coaxial cable with the outer braid removed, is used. Other windings, when necessary, may be placed over the grid coil.

In order to obtain design data, several formers were wound with various gauges of enamelled wire, and their resistances and self-capacitances measured by means of a Q meter at frequencies in the region of 50kc/s. During these measurements the core was not used, but the internal shield was earthed, as was the low potential end of the coil. Average values of these quantities are given in Table 1 under R_o and C_o. All the coils used work at frequencies below 200kc/s, and it was found sufficiently accurate to use a value of 50 for the Q of the Ferroxcube core, independent of frequency. Measurements of permeability were made on several cores, using flux densities between 200 and 3 000 gauss, and it was found that an average value of 2 500 would be sufficiently accurate for practical purposes. These values of Q and permeability were used in calculating Table 1. It was found during the measurements of self-capacitance and resistance, that the Q value of any of the coils at frequencies up to about 150kc/s could be calculated with fair accuracy by using the D.C. resistance of the coil in the usual Q formula. Owing to the tightness of the coupling, it is unnecessary to tune the anode coil to resonance with the secondary. In fact it is undesirable to do so, since tuning the anode coil is equivalent to doubling the capacitance of the secondary winding, and thus reducing its resonant impedance by a factor of 2. The range of wire gauges used is limited for two reasons. It is difficult to wind finer wires than 44 S.W.G., and if thicker wire than 32 S.W.G. is used, the insulation radially down the slots may be inadequate. Furthermore, the operating frequency becomes inconveniently high. For these reasons, data is given only for coils wound with wire from 32 to 44 S.W.G. inclusive.

It now remains to determine the optimum air-gap in the core for the various coils. This is done by finding the conditions which make the resonant impedance of the secondary a maximum.

Let L_o, C_o, R_o be the inductance, self-capacitance, and D.C. resistance of the coil, with no air-gap in the core, and let ω_o be the resonant angular frequency under these conditions.

Then

$$\omega_o^2 L_o C_o = 1$$

Further, let Q_{oc} be the Q of the coil with no air-gap, and neglecting core losses. Then

$$Q_{oc} = \omega_o L_o / R_o$$

If now an air-gap a is introduced, and the core has length l, and permeability μ, we have

$$L_x = \frac{L_o}{1 + x}$$

$$\omega_x = \omega_o \sqrt{(1 + x)}$$

$$Q_{xc} = \frac{Q_{oc}}{\sqrt{(1 + x)}}$$

where $x = a\mu/l$. Let Q_{oi} be the Q factor of the core with no gap, then

$$Q_{xi} = Q_{oi}(1 + x)$$

and if Q_x be the effective coil Q with an air-gap, including core losses,

$$Q_x = \frac{Q_{xi}Q_{xo}}{Q_{xi} + Q_{xo}}$$

Whence

$$Q_x = \frac{Q_{oi}Q_{oo}\sqrt{(1+x)}}{Q_{oi}(1+x) + Q_{oo}/\sqrt{(1+x)}}$$

The resonance secondary impedance is given by

$$R_x = \omega_x L_x Q_x$$

hence

$$R_x = \frac{\omega_o L_o Q_{oo} Q_{oi}}{Q_{oi}(1+x) + Q_{oo}/\sqrt{(1+x)}}$$

Putting $dR_x/dx = 0$ to obtain the maximum value of R_x, we obtain the following results:

$$1 + x = (Q_{oo}/2Q_{oi})^{2/3}$$
$$\omega_x = \omega_o(Q_{oo}/2Q_{oi})^{1/3}$$
$$Q_x = (2Q_{oi}Q_{oo}^2)^{1/3}/3$$
$$R_x = \omega_o L_o(4Q_{oi}^2Q_{oo})^{1/3}/3$$
$$\omega_x L_x = \omega_o L_o\,(2Q_{oi}/Q_{oo})^{1/3}$$

The values in Table 1 were calculated from these formulae. In each case, 6pF was added to the value of C_o before substitution in order to allow for wiring and rectifier stray capacitance, and for the small capacitive component of the load presented by the rectifier. This allowance for strays was found by experience to be a fairly good average value. High accuracy is unnecessary, because the curve of efficiency against air-gap has a broad maximum, and small errors in the various constants affect the efficiency only slightly. Other values used in the calculations were $Q_{oi} = 50$, $\mu = 2\,500$, $l = 22{\cdot}24$cm.

Practical Design

In choosing a coil for a given application, the following considerations are necessary. When the rectifier arrangement and the D.C. load to be supplied are known, the effective load resistance presented to the transformer may be calculated. Let this be R_L. Then, for satisfactory oscillator operation, since the loaded Q should not be less than 10 for a single valve, or 5 for a push-pull arrangement, the following condition must be satisfied:

$$\frac{R_L R_x}{(R_L + R_x)\,\omega_x L_x} \geqslant 10 \text{ or } \geqslant 5$$

In this case, the transformer efficiency is given by

$$\eta_T = \frac{100\,R_x}{R_x + R_L} \text{ per cent.}$$

The relation between R_L and the D.C. load resistance depends upon the rectifier arrangement adopted. For a half-wave rectifier, R_L is one-half the D.C. load, for a voltage doubler it is one-eighth, and for a tripler, one-eighteenth. There are therefore several possible values of R_L for any one D.C. load, and improvements in efficiency may be obtainable by using an alternative rectifier arrangement.

If voltage multipliers are used with coils operating above about 40kc/s, thermionic rectifiers are necessary, and the heater power required by the additional rectifiers may be greater than the power saved by increasing the transformer efficiency because of the lower value of R_L. For frequencies below 40kc/s, metal rectifiers may be used, with a consequent saving of power. In Table 2 are given values of D.C. load appropriate to various rectifier arrangements and to both single ended and push-pull oscillators, which give loaded Q factors of 10 or 5, depending upon the type of oscillator circuit used. If necessary, the loads may have slightly lower values than those given, though this may lead to loss of power and efficiency.

It will be seen that high transformer efficiencies are obtainable for a very wide range of D.C. load resistances. Having chosen a coil for a particular application on the basis of the foregoing discussion the next step is to design a class-*C* oscillator to supply the necessary power for the load, and for valve heaters where required. When this is done, the anode and grid voltage swings required will be known, and hence the numbers of turns required on the grid and anode coils. These are normally single layer coils, and the wire gauge is chosen so as to make the length of the coil nearly equal to the length of the core limb upon which it is to be placed. It is not necessary to tune the anode coil to resonance, but it is usually necessary to connect a small capacitance of about 50pF across the

TABLE 1

WIRE GAUGE (S.W.G.)	TOTAL TURNS	C_o(pF)	L_o(H)	$R_o(\Omega)$	a (×0·001 in.)	f_x(kc/s).	$\omega_x L_x$ (MΩ)	Q_x	R_x (MΩ)
32	800	6·9	1·15	36	63	180	0·069	634	43·4
34	1100	7·1	2·17	66	51	119	0·103	522	53·9
36	1600	7·3	4·60	140	39	71	0·169	403	68·1
38	2500	7·9	11·23	350	27	38	0·305	290	88·4
40	3800	8·6	25·95	800	19	21	0·522	214	113
42	5100	9·4	46·74	1440	15	13·5	0·756	175	132
44	7800	11·0	109·3	3360	10	7·2	1·294	128	166

TABLE 2

TOTAL TURNS	MINIMUM D.C. LOAD RESISTANCE MEGOHMS						TRANSFORMER EFFICIENCY PER CENT	
	HALF-WAVE RECTIFIER		VOLTAGE DOUBLER		VOLTAGE TRIPLER			
	SINGLE-ENDED OSCILLATOR	PUSH-PULL OSCILLATOR	S.E.	P.P.	S.E.	P.P.	S.E.	P.P.
800	1·4	0·7	5·6	2·8	12·6	6·3	98·5	99·3
1100	2·1	1·0	8·4	4·2	18·9	9·4	98·1	99·1
1600	3·5	1·7	13·8	6·8	31·1	15·4	97·5	98·8
2500	6·3	3·1	25·3	12·4	56·9	27·9	96·6	98·3
3800	11·0	5·3	43·8	21·3	98·6	47·9	95·3	97·7
5100	16·0	7·8	64·0	31·2	144	70·2	94·3	97·2
7800	28·0	13·5	112·0	53·9	252	121·3	92·2	96·2

anode coil in order to suppress parasitic oscillations at high frequency. This capacitor has a negligible effect upon the operating conditions. When large currents are drawn by the load, the power loss in the resistance of the secondary coil may become noticeable, and must then be allowed for. This is readily done in the same way as for normal power transformers. A further effect which may be observed is a slight variation of operating frequency with load resistance. One cause of this is the fact that the rectifier system acts as a load which has a small capacitive component, depending upon the duration of the charging pulse flowing into the reservoir capacitor. The duration of this pulse depends upon the load, so that variations of load cause slight frequency variations. Another cause which arises in the case of rectifier systems in which D.C. flows through the E.H.T. coil is the change with load of the D.C. magnetization of the core. This effect is also slight owing to the air-gap. Neither effect is normally of any practical importance.

From the foregoing discussion, it will be obvious that the limitation on efficiency will now be the efficiency of the oscillator itself. To obtain the highest efficiency in the oscillator, a power tetrode should be used. The oscillator should be designed so that at full load the anode of the valve just reaches the knee of the anode characteristic. When this is done, the best regulation will be obtained. Stabilization of output voltage is readily obtained where necessary by control of the screen voltage. It will be found that the grid capacitor has an optimum value, which is determined by experiment in a given case. The grid capacitor affects the overall efficiency by about 5 per cent.

In conclusion, three design examples will be given. The first two of these have given over two years' trouble free service and the third is an untried design.

Example 1

A unit to provide 2·5kV D.C. at 200μA, and 4V 1A for a cathode-ray tube heater. Using a half-wave rectifier, the A.C. load on the transformer is 6·25MΩ. The 2 500-turn coil is suitable, and gives a transformer efficiency of 93 per cent. The H.T. supply is 250 volts, and a 6AQ5 is used as the oscillator, with an EY51 as rectifier. Transformer details are: Anode coil 200 turns, grid coil 85 turns, rectifier heater coil 9 turns, tube heater coil 6 turns. The current drain is 30mA from the 250V line. Thus the input anode power is 7·5 watts, and the useful power output 4·5 watts, giving an efficiency of 60 per cent. The regulation from no load to full load is 4 per cent.

Example 2

A unit giving 6·6kV D.C. at 2mA, 4V 2A for C.R.T. heaters, and two floating supplies of 300V D.C. at 10mA. Using a half-wave rectifier, the A.C. load resistance is 1·65MΩ. The 800-turn coil is used, giving a transformer efficiency of 96 per cent. An 807 is used as the oscillator, and a U37 as the rectifier. The H.T. supply is 650V at a drain of 61mA. Metal rectifiers were used for the 300V supplies. Coil details are: Anode coil 60 turns, grid coil 12 turns, tube heater coil 1 turn, rectifier heater coil 1 turn with a dropper resistance, 300 volt coils 36 turns each, over grid coil. The input power is 39·6 watts, and the useful power output 27·2 watts, giving an overall efficiency of 68·8 per cent. The regulation from no load to full load is 6 per cent.

Example 3

A unit suitable for use in television applications, producing 7·5kV D.C. at 500μA. For a half-wave rectifier, the A.C. load is 7·5MΩ. The 5 100-turn coil is suitable, with an EY51 rectifier or a metal rectifier. A 6J6 used as a push-pull oscillator on a 300V supply would draw 20mA on full load. Coil details: Anode coil 170-0-170 turns, grid coil 20-0-20 turns, rectifier heater coil 6 turns. The overall efficiency will be 63 per cent, the regulation about 3 per cent per 100μA load current.

Acknowledgments

The author wishes to express his indebtedness to Mr. G. G. Scarrott, formerly of the Cavendish Laboratory, for several helpful discussions on the subject matter of this article, and to the Department of Scientific and Industrial Research, under whose auspices the work was carried out. The polystyrene formers used in the construction of the units described are produced by Messrs. J. F. Kenure Ltd, Feltham, Middlesex.

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Empirical Transient Formulae

For Systems with Flat or Peaked Frequency Responses

By Z. E. Jaworski*, Dipl.Ing., D.I.C.

Relation between the amplitude-frequency response of a network and its transient response is studied in terms of their respective "shape parameters". The shape parameters of both responses are defined and their interdependence is shown graphically for a number of networks. Empirical formulae linking the shape parameters of both responses are introduced.

THE performance of any linear network can be described by its frequency characteristic or its transient response. The usual practice is to design a system for a given frequency response and then check it for its transient response. As both responses are the solution of the basic differential equation of the system, and the link between them is provided by the Laplace Transform, the evaluation of the transient is straightforward mathematically, but unfortunately it is usually a very tedious and cumbersome job. Added to this lengthy operation is the fact that to extract certain data concerning the transient, one is forced to evaluate the whole response. Therefore a method of evaluation is needed, which would shorten the mathematical operation, and give the essential parameters of the step-function response, in terms of the main parameters of the amplitude-frequency characteristic.

This article sets out to establish, by correlation data, that these approximate relationships can be found for the following two classes of networks:

(a) Those having flat topped frequency response with a

*RCA Photophone Ltd.

single peak at zero (centre) frequency, $A_o = A_m$ for $x = 0$, and

(b) Those having peaked frequency response with two equal maxima symmetrical about zero (centre) frequency, $A_o \neq A_m$ and A_m for $x_m \neq 0$.

The method used in the investigation was that of trial and error, and the resulting formulae are purely empirical, with little theoretical support, apart from the fact that systems with similar frequency characteristics must have transients of similar shape.

Transient and Frequency Response

As the shape of the response is of primary consideration in this article, we start with a definition of the important parameters of both responses.

(a) The Transient Response

The term transient response will refer here to the time variation $Q(t)$ of the output of a system which has been excited by a unit step function. If such a function, having an amplitude $U = 0$ up to a time $t = 0$, and $U = 1$ for all time $t \geqslant 0$, is applied to a linear system, its output has

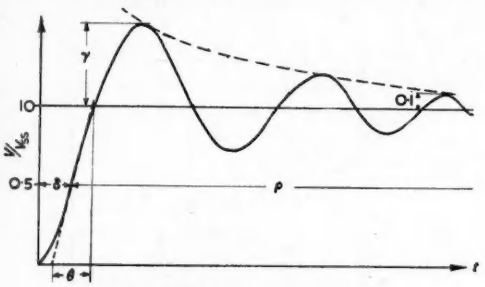

Fig. 1. Typical transient response

the general form:

$$Q(t) = 1 + \sum K_n \exp s_n t$$

where:

K_n is a coefficient dependent on system parameters and the particular root of the equation, and

s_n is a root of the characteristic equation of the system.

This response can be derived from the differential equation of the system by any analytical method or can be measured experimentally by taking oscillographic recordings of transient responses from the existing network. An ideal network should reproduce any variation of input without noticeable distortion. This, however, is not physically possible due to the presence of stored energy throughout various parts of the system. Consequently, the actual transient response has always a definite rise time and possibly some transitory oscillation. Such a response is found only in stable systems and it is to these systems that this article is limited.

Fig. 1 shows a typical transient response to a unit step, where:

θ is the rise time defined as the time taken by the tangent to the response curve (at half of the steady state value) to reach the steady state value of the response.

γ is the overshoot defined as the difference between the first maximum value of the response curve and the steady state value.

$\rho_{(1\%)}$ is the relaxation time defined as the time taken from the mid-point amplitude of the transient response, to the moment when the envelope to the response deviates from the steady state by a prescribed proportion of the steady state value.

δ is the time delay defined as the time taken by the response curve to reach half of its final value.

τ is the period of oscillation at the top of the response.

The above defined parameters will be referred to in the rest of the article as the "shape parameters" of the transient response. The three parameters of most practical importance are, rise time, overshoot and relaxation time.

(b) The Frequency Response

The term frequency response refers to magnitude and phase relationships between the input and the output functions of the system, when the time variation of the input is sinusoidal. If a sinusoidal function:

$$Q_I = A_I \, e^{j\omega t}$$

is applied to the input of a linear network, the resulting output:

$$Q_o(t) = A_o \, e^{j[\omega t - \phi]}$$

is also sinusoidal, having the same frequency as the input

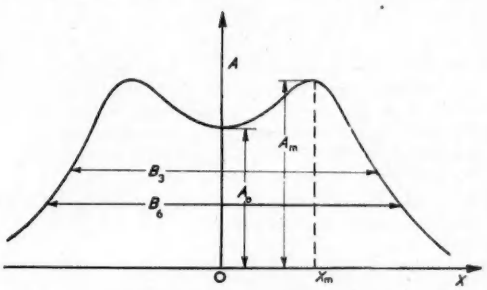

Fig. 2. Typical frequency response

but a different amplitude and phase. Their ratio:

$$Q_o/Q_I = M(\omega) \, e^{-j\phi(\omega)}$$

independent of time, is a complex function of the network constants and the angular frequency ω. It determines the transmission property of the network and is known as the frequency characteristic of the system. Being a complex function, the frequency characteristic is presented graphically by two diagrams, showing amplitude/frequency and phase/frequency relations. The graphical representation takes precedence over the analytical in cases where it is simpler to measure the frequency response than to calculate it.

Another factor to be taken into account is the relation between the phase and amplitude characteristics of the system. It was proved by Bode that these two characteristics are strictly related for all minimum phase shift networks. As the majority of practical networks are such, one is released from the necessity of studying the two characteristics separately and remain with the choice of either. Because the amplitude/frequency characteristic is more commonly used and much easier to determine experimentally than the phase characteristic, it was decided to use the former as the basis for investigation.

Fig. 2 shows the general form of the amplitude-frequency response.

Here:

$x = \omega/\omega_o$ is the normalized frequency taken as the ratio of the angular frequency ω to some particular frequency ω_o (e.g. resonance frequency) of the system.

x_m is the value of the normalized frequency for which the response exhibits a maximum.

A_o is the frequency invariant giving the amplitude of the response at zero (centre) frequency.

A_m is the maximum amplitude of the response.

B_3 is the bandwidth at the level 3db (0·707) below zero (centre) frequency value.

B_6 is the bandwidth at the level 6db (0·5) below zero (centre) frequency value.

The form of the frequency response shown on Fig. 2 can be attributed, either to a low-pass network or a band-pass one. In the former case $x = 0$ is the zero frequency of the response, and in the latter, $x = 0$ corresponds to the centre frequency of the response. For band-pass networks, Fig. 2 represents the response of the network for positive frequencies only. The response for the negative frequencies is omitted as contributing negligibly to the transient.

The parameters A_o, A_m, B_3, B_6 are of special interest here and henceforth these parameters will be referred to as "shape parameters" of the frequency response.

It was found necessary during the investigation to derive a more descriptive shape parameter and the new parameter, called the "Form Parameter" was defined as:

$$F_p = \frac{B_3}{B_6}\frac{A_m}{A_o} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

This parameter is dimensionless and being the product of two ratios, is independent of the dimensions of either B or A. For flat frequency responses, the ratio A_m/A_o equals unity, and the whole form parameter reduces itself to the simple ratio of B_3/B_6, which describes the slope of the frequency response curve.

For ideal filters, having a rectangular frequency characteristic, the value of form parameter F_p is unity.

Approximate Transient Formulae

Using the above defined shape parameters, the following approximate relationships have been established:

Rise Time

Rise time in the transient response is the measure of failure imposed by the physical nature of the network, to follow accurately any sudden change of the input signal. The usual practice is to decrease rise time as far as other considerations will permit. The importance of rise time in design is probably responsible for at least three different definitions, all of which are in common use today. One defines rise time as the time taken by the tangent to the response curve (at the maximum slope of its leading edge) to reach the steady state value of the response. Another defines it as the time within which the transient rises from 0·1 to 0·9 of its final value, and yet another has it as the time taken by the transient to reach 0·85 of its final value from the beginning of the transient.

All these definitions have their justification and it is difficult to decide which one should be accepted as standard. The one used here is similar to the first of the above three and has the additional advantage of being easier to determine. These two similar definitions give the same results for multi-stage amplifiers where the maximum slope tends to occur near the half amplitude point as the number of stages increases, and also in the case of ideal filters where the maximum slope occurs at exactly half amplitude. Using our definition of rise time the well-known[7] formula:

$$\theta = 1/B_6 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

was calculated for all the systems under consideration. The results are plotted on Fig. 3 in the form of θB_6 against the different values of the overshoot.

It can be seen from this diagram that the average error introduced by this formula is not greater than 15 per cent. In equation (2) θ has the dimension of time units and B_6 is in cycles per time unit. If B_6 is expressed as a normalized frequency, θ is then expressed in time units multiplied by ω_o. Using the form parameter, equation (2) can be rewritten as follows:

$$\theta = \frac{F_p}{B_3}\frac{A_o}{A_m} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Overshoot

The next parameter of importance is overshoot. There is fair agreement as to its definition and the one used here is that generally accepted. There are certain applications where a degree of overshoot is permissible, but in general, the less overshoot the better.

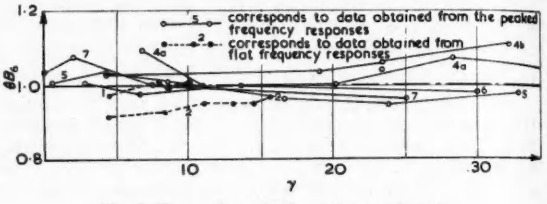

Fig. 3. The product of θB_6 against overshoot Y

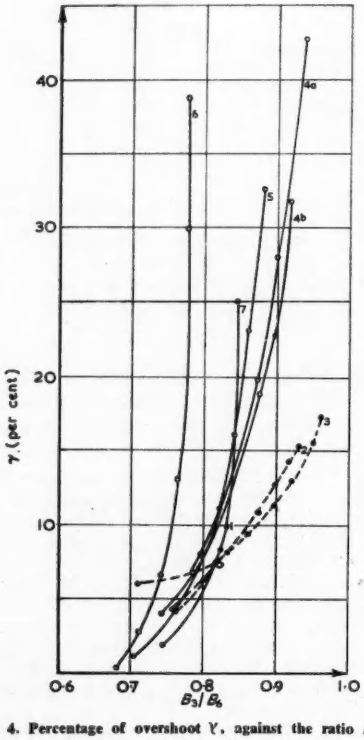

Fig. 4. Percentage of overshoot Y, against the ratio B_3/B_6

The dependence of the overshoot on the slope of the frequency response can be seen on Fig. 4, where the calculated values of overshoot are plotted against the corresponding ratio B_3/B_6. In general, overshoot increases with an increase in the slope, but the speed of increase is different according to whether the circuit has a flat frequency response or a peaked one. In peaked response circuits, the overshoot grows more quickly than in flat topped circuits. This different rate of increase disappears when overshoot is referred to the form parameter. Fig. 5 shows the variation of overshoot with form

parameter as evaluated for all the circuits considered.

The relation between overshoot and form parameter as derived from the above diagram, is given by the formula:

$$\gamma = 58 F_p - 39 \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

Here γ is given as a percentage of the steady state value of the respone and form parameter F_p is dimensionless. The average error given by this formula is 14 per cent and the maximum error is never more than 25 per cent. It should be noticed also that the absolute error increases with an increase in overshoot.

Relaxation Time[9]

The last transient shape parameter of importance is relaxation time. It measures the time which the transient oscillations on the top of the response, take to die away. It can also measure the amount of damping existent in the circuit. The bigger the damping, the shorter the relaxation time and vice versa.

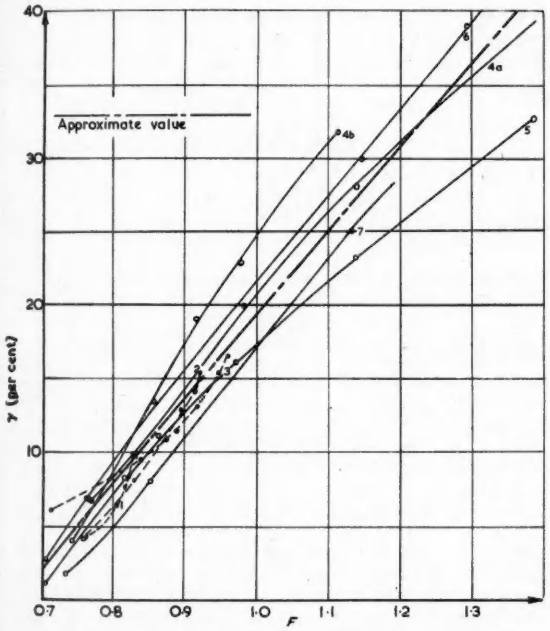

Fig. 5. Percentage of overshoot Υ, against the form parameter F

Two values of relaxation time were considered: $\rho_{(1\%)}$ and $\rho_{(0\cdot1\%)}$. They were evaluated for all the networks investigated and their dependence on the form parameter was studied.

Fig. 6 gives the variation of $\rho_{(1\%)}$ and of $\rho_{(0\cdot1\%)}$ with the form parameter. The approximate formulæ for relaxation time were derived by the same method as that for the overshoot, and the results were as follows:

$$\rho_{(1\%)} = 1/B_6 \ (7F_p - 3) \quad \ldots\ldots\ldots \quad (5)$$

$$\rho_{(0\cdot1\%)} = 1/B_6 \ (9F_p - 3) \quad \ldots\ldots\ldots \quad (5a)$$

What was said previously regarding the dimensions of rise time, applies now to relaxation time. The total root mean squared error, introduced by equation (5) is 18 per cent and that introduced by equation (5a) is 25 per cent.

Time Delay and Oscillation Period

The remaining two parameters are of little use in practice, and are only included here to complete the parametric description of the transient response.

Time delay is dependent on the phase relationship between components of the frequency spectrum and of the unit step. For networks with a linear phase characteristic near centre frequency, time delay is given by the following formula:

$$\delta = [d\phi/dx]_{x=0} \quad \ldots\ldots\ldots\ldots\ldots \quad (6)$$

In this formula ϕ represents the phase shift of the network in degrees. Time delay is a function of the number of stages and generally increases with them. The rate of increase is dependent on the type of network concerned.

The period of oscillation at the top of the transient

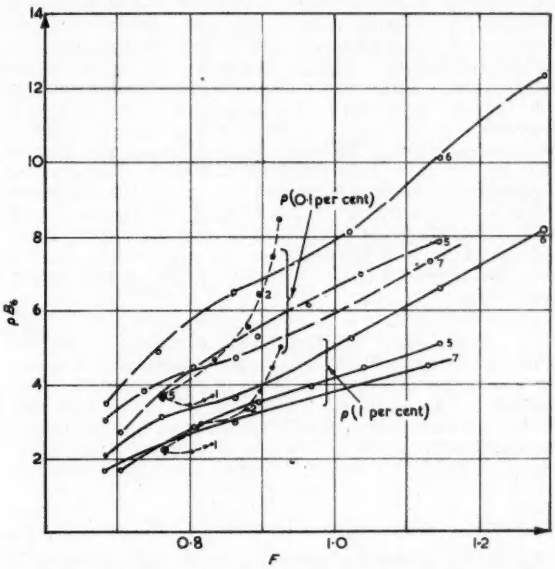

Fig. 6. Relaxation times $\rho(1.0\%)$ and $\rho(0.1\%)$ against for parameter F

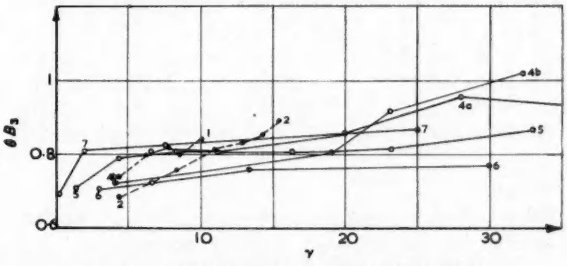

Fig. 7. The product of θB_3 against overshoot Υ

reciprocates approximately the cut-off frequency of the low-pass network. For networks whose frequency responses exhibit a resonance peak, the period of oscillation is roughly equal to the reciprocal of the resonant frequency:

$$\tau = 1/f_c \quad \ldots\ldots\ldots\ldots\ldots \quad (7)$$

where f_c is either the cut-off or resonant frequency.

An attempt to represent the last two parameters as a function of the form parameter, was unsuccessful.

Relation Between Overshoot and Rise Time

Combining the equations (2), (3) and (4) the following expression is arrived at:

$$\theta B_3 = \frac{(\gamma + 39)A_o}{58 F_p A_m} \quad \ldots\ldots\ldots\ldots \quad (8)$$

which relates overshoot to rise time. The values of θB_3 were calculated from equation (8) and plotted on Fig. 7

against the increasing overshoot. The results were checked by using separate values for θ and B_3, which were derived directly from the corresponding responses of considered networks.

The curves of Fig. 7 show that the product θB_3 has a tendency to increase with a rise in overshoot. This somewhat startling result can be physically explained in the following way.

Rise time depends on the particular relationship between the individual component frequencies of the unit step spectrum which pass through the network. The minimum rise time is obtained if and when all contributing sine waves reach their greatest slope simultaneously. For the component frequency having the same amplitude, the slope will increase with the frequency. As the amplitude of the contributing frequencies of the unit step spectrum diminishes with frequency, the resulting contribution to the slope is roughly the same for each harmonic. This is true for the ideal filter. In any real filter, the effect of higher harmonics is still further reduced by the particular frequency characteristic of the network. In general it can be said that the slope (reciprocal of rise time) of the transient response is proportional to the bandwidth and can never be higher than the maximum slope of the highest contributing harmonics.

From equation (8) it is seen that for a constant B_3, the value of rise time increases (slope diminishes) with the increase of overshoot. This increase of overshoot is necessarily accompanied by an increase of form parameter. The increase of form parameter in flat frequency responses having a constant B_3 can only be achieved by diminishing the bandwidth at B_6. Thus, the number of higher harmonics which can be passed through the filter is reduced, and as a result, the rise time is increased.

Conclusions

From the previously presented formula, it is possible to derive a set of rules governing the behaviour of the transient response. Taking the transient shape parameters in the same order as given in this article, it can be said that:

Rise Time

(a) Decreases with the increase of bandwidth at 6db level.

(b) Increases slightly with the gain in overshoot for a constant bandwidth at 3db level.

Overshoot

(a) Increases with an increase of the form parameter.

(b) For the flat frequency response, decreases with the decrease of the ratio B_3/B_6.

(c) Is greater for a peaked response than for a flat response with the same ratio of B_3/B_6.

Relaxation Time

(a) Increases with an increase of the form parameter.

(b) Decreases with the increase of bandwidth at 6db level.

These rules apply only to the two previously specified groups of networks, and even there they only represent general trends of behaviour.

From the above it can be finally concluded that the network capable of reproducing a unit step with the least distortion, should have a frequency response of trapezoidal form. Its bandwidth at 6db level should have the greatest permissible value, and the ratio B_3/B_6 should be less than 0·5. Such a network could be defined as an "ideal transient filter" as against the commonly known "ideal (frequency) filter." Thus it can be seen that conditions for the ideal frequency response are incompatible with those for the ideal transient response and the degree of compromise lies with the designer.

Acknowledgments

The author wishes to acknowledge the help received from Prof. Z. Jelonek, who initiated and supervised the investigation. He also wishes to thank his colleague, Mr. Demczynski for permission to include the formula for the relaxation time in this article.

Appendix

Formulae for the Frequency/Amplitude Responses Responses of the Networks

Nomenclature:

M—modulus of the response,

n—number of stages,

x—normalized frequency,

f—critical frequency of the network.

Flat Responses

(1) *Critically Coupled Pairs*[7]

$$M_1 = (1 + x^4)^{-n/2}$$

where

$$x = 2Q\Delta f/f_0 \text{ and } B_3/B_6 = \sqrt[4]{\left(\frac{2^{1/n} - 1}{2^{2/n} - 1}\right)}$$

(2) *Staggered n-tiples*[3]

$$M_2 = (1 + x^{2n})^{-1/2}$$

where

$$x = 2Q\Delta f/f_0 \text{ and } B_3/B_6 = {}^{1/2n}\sqrt{3}$$

(3) *Low-pass Filter with Semi-infinite Constant Slope Response*[5]

$$M_3 = 1 \text{ for } 0 < x < 1$$

and

$$= x^{-n} \text{ for } 1 < x < \infty$$

$$B_3/B_6 = {}^{n}\sqrt{0{\cdot}707}$$

Peaked Responses

(4) *The Compensated RC Amplifier*[6]

$$M_4 = \left\{\frac{1 + (xQ)^2}{(x/Q)^2 + (x^2 - 1)^2}\right\}$$

$$Q = 1/k = 1/\omega_0 RC$$

(4a) $k = 1{\cdot}41$

(4b) $k = 1{\cdot}51$

(5) *Series Peaking Coil*[4]

$$M_5 = \left\{x^4 + x^2(1/Q^2 - 2) + 1\right\}^{-1/2}$$

(6) *Shunt Peaking Coil*[4]

$$M_6 = \frac{1 + (xQ)^2}{(x/Q)^2 + (x^2 - 1)^2}$$

(7) *Simple Servo Mechanism*[1]

$$M_7 = \left\{(1 - x^2)^2 + (2\rho x)^2\right\}^{-1/2}$$

$$f_0 = 1/\pi \sqrt{(k/J)}$$

$$\rho = f/2\sqrt{(kJ)}$$

k—stiffness

J—inertia.

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A Compensated Square Wave Phase Discriminator

By R. Caldecott*, B.Sc.

THIS square wave phase discriminator was developed to meet the special needs of the servo system in an equipment used for the automatic recording of V.H.F. aerial radiation patterns. The demands made on this type of equipment are very exacting and, at low signal levels, a very high degree of stability is required in order that the signal shall not be "lost" among the random fluctuations in the various component circuits, in particular, in the phase discriminator. The following circuit was devised with a view to compensating the effects of all external variations other than those of the input signal.

The Circuit of the Phase Discriminator

An examination of the circuit (Fig. 1.) shows that it consists principally of four triode-hexode mixers, whose hexodes are arranged in a form of bridge network. The valves are connected in pairs (X and Y), each pair sharing a common anode load.

The reference signal consists of two anti-phase square waves, of approximately 100 volts peak-to-peak, injected at the terminals A and B. A square wave is fed to a phase-splitter to provide the reference signal or two anti-phase square waves may be generated by a suitable device. The square waves are fed through two Westectors (WX6) and the diode-connected triode sections of the X78 valves. This arrangement clamps the mixer grid at cathode potential while the reference signal is positive and provides a large cut-off potential when it is negative. The effect of any variations in the amplitude and waveform of the reference signal upon the phase discriminating properties of the circuit is, thus, minimized.

It will now be apparent that only one of the hexodes passes current through each anode load at any given instant and that, provided the reference signal has a steep wave-front, immediately one valve of a pair ceases to conduct, the other conducts. Thus, a steady current flows through each anode load resistance and provides a steady output which is independent of relatively wide variations in the mark-space ratio of the reference signals. When the circuit is in a balanced condition, the current in the two anode loads is equal and the output is zero.

Consider now the effect of applying a square wave signal, which is of unknown amplitude but either in phase, or in anti-phase, with the reference signal, at the point marked "input" in the diagram. This signal is divided into two equal anti-phase components by means of the L77 phase splitter valve. Suppose, for the sake of argument, that the upper two valves are conducting and that the unknown input signal is on its positive excursion, i.e., in phase with reference signal A. There will then be a decrease in current in the left-hand hexode anode load and an equal increase in the right-hand load. On reversal of the reference signal, the lower two valves will conduct and, since the unknown signal will also have reversed in phase, the previous current changes will be maintained. Thus, a steady D.C. output whose amplitude is dependent upon the amplitude of the input will be obtained. When the input signal is in phase with the reference signal B, the sense of the output is reversed.

As a precaution against undesired fluctuations, the H.T. supply is stabilized and a neon stabilizer is provided for the screens of the hexodes. Variations due to changes in valve constants are, of course, minimized by the balanced nature of the system. The phase discrimination of the circuit is, thus, made substantially independent of all normal variations in supply voltages or, as already stated, of changes in the amplitude of either of the signals or their mark-space ratio. However, the maximum sensitivity of the circuit and, hence, the maximum value of the output signal, is only obtained when the mark-space ratio of the input and reference signals is the same.

The response of the circuit has been found to be almost linear for inputs up to 1·75 volts R.M.S. with an overall gain of 34 times, where the gain is defined as the ratio.

$$\frac{\text{D.C. output voltage}}{\text{R.M.S. input voltage}}$$

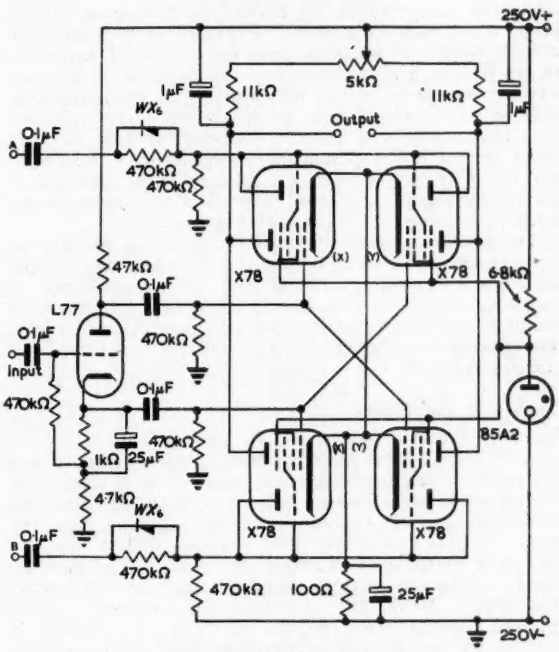

Fig. 1. The circuit described

Applications of the Circuit

In the foregoing description, only signals which are either in phase, or in anti-phase, with the reference signal have been considered. However, if a signal of constant amplitude but continuously variable phase is injected, the output will be a measure of the phase-angle and will be zero in the quadrature condition.

So far, the discussion has been limited to square waves. The circuits has, however, been operated with equal success using sine wave input signals, the output being slightly less smooth in this case. The output will consist of half sine waves which are, however, smoothed by the capacitors connected across the output load resistors. No attempt has yet been made to use a sine wave as a reference signal but, providing the amplitude is sufficiently great, the limiting device in the reference signal input circuit will ensure satisfactory results.

Acknowledgment

The author wishes to thank E.M.I. Engineering Development Ltd for permission to publish this article.

* *E.M.I. Engineering Development Ltd.*

Electrophoresis in the Valve Industry

By L. E. Grey*, B.Sc., and R. O. Jenkins, A.R.C.S., D.I.C., Ph.D., F.Inst.P.

The deposition of particles from a suspensoid by the application of an electric field is widely used in the valve industry for coating components. This process, known as electrophoresis, necessitates very careful control of impurities providing ions which form a charged double layer on the particles. Emissive filament, heater and insulator coating methods using electrophoresis are described.

ELECTROPHORESIS is an unfamiliar process to most scientists and technicians, although it is closely analogous to the well known process of electroplating. Electroplating, of course, consists of deposition of a metal on to the negative electrode when D.C. is passed between two electrodes immersed in an electrolyte containing appropriate metal salts in solution. Electrophoresis consists of the deposition of small particles on to one of two electrodes placed in a suspension of the particles in a liquid when a voltage is applied between them. These particles may be sub-microscopically small or may be of the order of a few microns (10^{-3}mm) in diameter. If they are very small, they will stay permanently suspended in the liquid, and the mixture is known as a colloidal suspension, but if greater than about a micron, they will slowly settle to the bottom, and the mixture is called a suspensoid.

The process of electrophoresis is used in a number of ways in the manufacture of radio valves when controllable and quick deposition of particles from suspensoids is required, and it enables operations which are otherwise wasteful and tedious to be done economically and easily. The process thus contributes to the reliability of valves and reduces their cost.

Theory of the Process

The Movement of Particles

A very early experiment by Reuss in 1808 demonstrated the effect of electrophoresis very clearly. Two tubes containing water were inserted into a mass of wet clay and a voltage applied between electrodes dipping into the tubes. It was found that clay particles moved into the tube with the positive electrode, and water out of the clay mass into the tube with the negative electrode. To explain the effect, Helmholz postulated the existence of a charged double layer on the particles. According to this theory, the particles suspended in the liquid, acquire a layer of negative charges, while the liquid surrounding it becomes correspondingly charged by an equal amount of positive charge. When an electric field is applied across the liquid, the negatively charged particles will tend to move towards the positive electrode and the positively charged liquid toward the negative electrode.

If the state of affairs in the suspension is idealized as in Fig. 1, the velocity v of the particle in an electric field dE/dx is:

$$v = \frac{\epsilon V}{6\pi\eta} \cdot \frac{dE}{dx}(1 + r/\delta)$$

where ϵ is the dielectric constant of the liquid, η the viscosity of the liquid, V the potential difference between the particle surface and the contra-charge layer in the liquid, r the particle radius, and δ the distance between the particle surface and the contra-charge layer. This formula agrees with experiment in showing that the velocity is almost independent of particle size (as r/δ is small) and is proportional to the field. The value of V and δ depend largely on the concentration and valency of the ions in solution. It may be seen immediately that the efficiency of the process will depend largely on the presence of a small amount of the right kind of ions being present in the liquid. This in turn depends on the presence of a small amount of an appropriate electrolyte in the otherwise insulating liquid.

The Stability of Suspensions

Providing particles of a few microns diameter do not coalesce in the suspension, they settle out relatively slowly, while if they are much smaller than a micron, the Brownian movement will keep them in suspension permanently. Some suspensions, however, settle very quickly because the small particles coagulate. It may be seen from Fig. 1 that as particles with a double layer approach one another, providing the contra ions in the liquid are fairly diffusely distributed, the like charged particles will repel each other before contact. Only those with highest Brownian velocity, will come close enough for surface attraction forces to come into play and cause coagulation. If, however, the contra ion concentration is high close to the particle, they will be able to approach much closer to each other because the presence of the contra ions will neutralize the repulsion of the charges on the particles. There will thus be a much greater chance of coagulation taking place, and this may happen if the concentration of electrolyte becomes too high. The chance of this happening also increases if the particle concentration is high. In addition, it has been shown that as the valency of the contra ion increases, the distance between the contra ion layer and the particle decreases rapidly. Thus very small concentrations of trivalent contra ions such as aluminium, will have a marked effect on rate of electrophoresis and relatively little will cause coagulation, whereas the concentration of monovalent contra ions, such as sodium, will not be so critical. With most suspensions considered here,

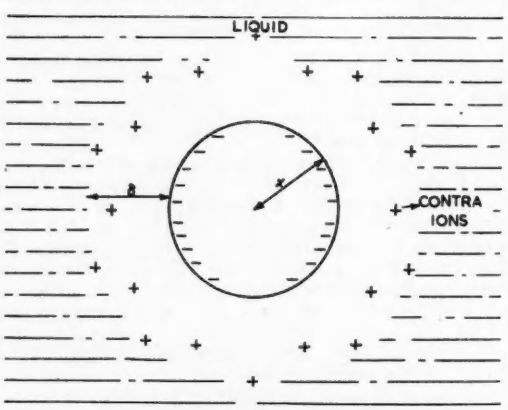

Fig. 1. Particle with charged double layer

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the ions giving the double layer are derived from an electrolyte in the liquid. This electrolyte in turn may be present due to solution of adsorbed impurities on the original solid particles, which dissolve in the liquid and provide a source of ions. This occurs more easily if the liquid is water or contains water as an impurity.

It may thus be seen that conditions for good electrophoretic deposition and good stability of the suspension both depend on provision of the right kind of ions in a suitable concentration. This can only be controlled by extreme care to ensure that the solid particles are free from soluble impurities and that any organic liquids used are water-free, thus any necessary electrolyte can be introduced in the exact quantities required. The actual sign of the charge on the particles and hence whether they deposit on the anode or cathode, depends both on the nature of the particle and the liquid. Basic substances in water tend to become negatively charged, acidic substances positively charged, while neutral substances are usually negatively charged because the negatively charged hydroxyl ion is more easily adsorbed on their surface. When organic liquids are used for the suspending medium the sign of the charge will depend on small quantities of impurities on the particles and also on water or electrolyte already present or added to the liquid.

Processes in Valve Making

EMISSIVE COATINGS: BATTERY FILAMENTS

One important application of electrophoresis in valve making is in the preparation of the thermionic oxide coated cathode. The cathode of a battery valve consists of a very thin nickel or tungsten wire coated before assembly into the valve, with a layer of co-precipitated barium strontium and calcium carbonates. These wires are usually less than 0·001in thick (finer than a human hair), and have to be coated to at least double their thickness with the carbonate layer. This layer can be applied by dragging the wire through a sludge of the carbonate and then baking it on by passing the wire through an oven at about 600° C. This can be a tedious process as many passes are necessary and the high temperature may anneal and weaken nickel wire, or cause oxidation of tungsten wire and thus adversely effect the final performance of the valve.

The carbonates may, however, be applied to the wire by electrophoresis, by passing it through a suitable suspension of the carbonate particles in an organic liquid and applying a voltage between the wire and a surrounding electrode. The coating can thus be applied in a single pass without any high temperature treatment which might spoil the final cathode.

The carbonate particles are usually approximately 1 micron diameter and some agitation of the suspension is necessary to prevent them from settling out. The adhesion of the carbonates to the wire must be sufficient to allow subsequent handling during mounting and some form of binder must be applied to the deposited carbonate layer to provide the necessary adhesion. In one process the carbonates are suspended in a solution of nitro cellulose in various organic solvents and the composition of the suspension is adjusted so that both the nitro cellulose and the carbonates deposit simultaneously on the wire to give a layer with the necessary adhesion.

The co-precipitated carbonates are ball milled into a solution of nitro cellulose in butyl acetate, acetone and methyl alcohol. To provide the necessary free ions to give the charged double layer on the carbonate particles, a small amount of electrolyte is added. This must not harm the final cathode, and strontium nitrate solution in water has been found very suitable, the particles becoming negatively charged.

A diagram of the plant is shown in Fig. 2. The wire is drawn off the spool and passes over a metal pulley and down through an insulated guide to a pulley of bakelite at the bottom of the coating bath. The wire then comes up to the surface of the bath in the centre of an electrode, thence through a low temperature drying oven to evaporate the organic solvents from the coated layer before it passes over the final pulleys and is spooled. A potential is applied between the wire via the first pulley and the electrode in the bath, the wire being made positive. The thickness of the coating applied can be varied by adjusting the voltage which is usually of the order of 50 volts, and the wire passes through the plant at about 10ft per minute.

It is necessary to provide some form of stirring to prevent the particles of the suspension settling to the bottom and this may be accomplished by having inclined fins on the outside of the open mesh cylindrical electrode in the suspension and rotating the bath on its vertical axis at about 100 rev/min. This type of suspension has an appreciable electrolytic conductivity and a current of some milliamperes passes during the coating process.

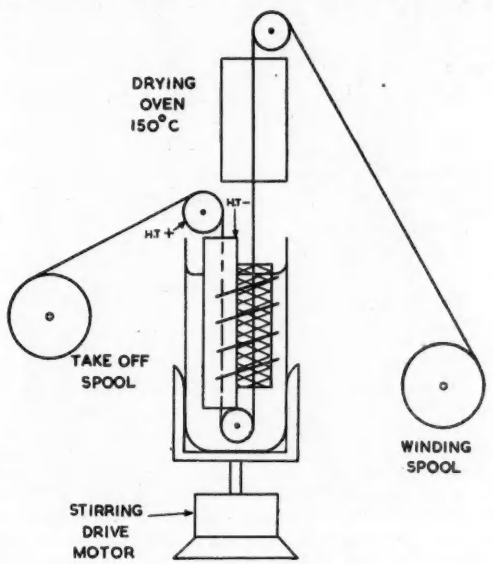

Fig. 2. Plant for coating wire

The alternative process applies the carbonates from a suspension in one of the alcohols in the range from methyl to amyl alcohol. In this case, the particles take up a positive charge, and the wire must, therefore, be made the cathode in the coating bath. As the wire passes through the suspension, it becomes coated with the carbonates, but without binder. Before contacting any pulleys or guides, the alcohol must be evaporated from the coating by passing the coated wire through an oven, and a binder such as nitrocellulose solution or molten paraffin wax applied to the wire, by passing it through the binder carried in the deep groove in a pulley, or some other suitable applicator. The plant can be laid out in a similar manner to that previously described or it can be arranged horizontally and the suspension stirred by circulation. The voltage across the coating bath is of the order of 50 volts, and a coating speed of a few feet per minute is usually employed.

Suspensions for this process are very poor electrical conductors and the current through the bath is less than a milliampere. These suspensions have a considerable tendency to coagulate and will not coat satisfactorily if the ion concentration rises above a very low value and

it is, therefore, essential to use very pure water-free alcohol. The carbonates must also be well washed and precipitated in such a manner as to avoid excessive adsorbed impurities. One other difficulty sometimes encountered is that although the particles migrate to the wire, surface tension forces strip the coating off as it leaves the surface. This is caused by the particles carrying excess liquid with them, and usually is associated with a slight tendency to particle coagulation in the suspension.

RECTIFIER STRIPS

A directly heated rectifier cathode consists of a length of nickel ribbon about 1mm wide, coated initially with co-precipitated barium, strontium, and calcium carbonates. This coating can be carried out by dragging the strip through a sludge previously described for wire coating, but it has been found that the cataphoretic coating process has some advantages. Due to surface tension forces, the sludge method gives a coating with the cross section shown in Fig. 3(a). By using cataphoretic coating, a strip with cross section as in Fig. 3(b) can be obtained, and such a strip gives a better thermionic emission which is very desirable.

The suspension used is similar to that containing nitrocellulose, as described previously. For strip coating, a plasticizer is usually advisable, as pure nitrocellulose

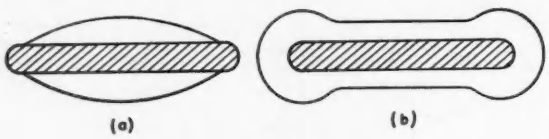

Fig. 3. Cross-section of filament strips
(a) *drag coated.* (b) *cataphoretically coated*

binder is rather brittle. The usual plasticizers such as dibutyl pthalate or camphor are found quite suitable. The plant is similar in layout to that used for wire coating, but it has been found that more satisfactory quick drying can be obtained by warming the strip by radio frequency eddy currents, and thus drying the coating from the inside. The strip passes through a coil 9in long and 1in diameter carrying the radio frequency current. On this plant, the strip can also be given a channel section before coating, by passing through suitable rollers, and it thus has greater inherent rigidity in the final valves.

Heater Coating

WIRE COATING

The mains valve cathode consists of a nickel tube of rectangular, oval or circular cross section coated on the outside with the normal barium strontium calcium oxide. To maintain it at 750°C the nickel tube contains a heater which must be electrically insulated from the cathode. The insulation resistance must be at least 10MΩ at running temperature. Such heaters are made from tungsten or molybdenum tungsten alloy wire coated with a layer of pure aluminium oxide. The heater can be made from a straight wire bent into a multi-limb form, or maybe a double helix or a small coil bent into a V. The multi-limb type of heater is usually made by pre-coating the wire with alumina and then winding it round a sharp edged former similar to a double-edged razor blade. To make this heater successfully, the coating must have a good adhesion and should not break off at the bends, but only crack locally, and there is then little danger of the tips of the bends short-circuiting with each other. This pre-coating can be accomplished very successfully by electrophoresis. The process is similar to that for coating emitting filaments from a suspension using binder.

Pure alumina with a crystal size of the order of 1 to 5 microns, is ball milled into a nitrocellulose solution in acetone and methyl alcohol. Various additions have been used to provide the free ions necessary to form the double layer, and make electrophoresis possible. The most effective is a small controlled amount of ordinary salt solution. The chlorine ions are adsorbed on to the alumina particles which become negatively charged, and are deposited on the wire given a positive potential in the bath. The wire is passed through the apparatus shown in Fig. 2 at a speed of about 15 feet per minute, and a layer 0·06mm thick is applied. The variation in the speed of coating with the addition of salt solution to the suspension is shown in Fig. 4. These are experimental curves taken with a current of 50mA flowing through the bath. It may be seen that the optimum ion concentration is obtained when the quantity of sodium chloride is 0·2 per cent of the alumina content. To ensure sufficient water to ionize it properly, the salt must be added as a solution at a concentration of not more than 3 per cent. If this concentration is exceeded, there is

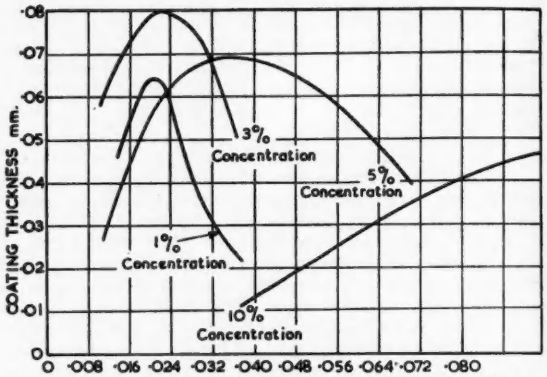

Fig. 4. Effect of salt on coating of alumina

not enough water to ionize the salt sufficiently, and more salt is necessary.

When excess water is added, the conductivity of the bath increases, and the applied voltage to give 50mA drops. As the rate of deposition is proportional to the field, the coating thickness drops correspondingly. The current must be limited to about 50mA as the excess gas produced by electrolysis disrupts the coating.

It has been found essential that the alumina is well washed so as to be free from soluble impurities, particularly those with divalent or trivalent ions which would decrease the speed of coating. Also, if excess electrolysis takes place, the gases produced may spoil the texture of the final coating.

When the wire has been coated, the heaters are made by winding on a former, and are inserted in alumina tubes. They are then heated at about 1 600°C for a few minutes in hydrogen in a molybdenum wound tube furnace to remove the nitrocellulose binder and sinter the alumina into a hard coating. The tips of such heaters are shown in Fig. 5 compared with those obtained with the alternative drag coating process.

TIP COATING

In certain high voltage low current heaters, a large number of limbs of thin wire are necessary, and relative movement of the limbs and short-circuiting between tips may take place. This can be avoided by dipping the end of the heater into a bath containing a suitable cataphoretic suspension and applying coating locally on the tips. A suspension of finely divided bentonite clay in water can be used for this purpose.

Coiled Heater Coating

It is possible to coat preformed coiled heaters by electrophoresis. Coating the reverse helix type is not very satisfactory, as the suspension tends to be retained by the coil on withdrawal from the bath, causing uneven coating and turns which are locked together, and the relatively wasteful method of spraying is therefore usually adopted. The close wound coil formed into a V can, however, be coated very satisfactorily by electrophoresis. The coils are usually of tungsten, wound on a molybdenum mandrel which can be left in position for the coating process. The heaters are held in a clip with the vertex of the V downwards and dipped into the coating bath to the required depth, the voltage applied for a few seconds and the coated heaters then withdrawn. This process can be mechanized on a multi-head machine or done on a semi-mechanized single head machine as described in the next section. The coated heater is sintered in hydrogen at

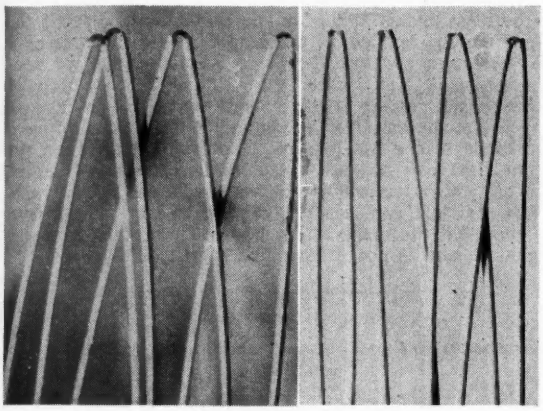

Fig. 5. Heater tips (× 10)
(left) *drag coated* (right) *cataphoretically coated*

1 600°C and the molybdenum mandrel dissolved in acid subsequently.

Suspensoids containing nitrocellulose binder can be used, although their relatively high viscosity gives a tendency for liquid to be retained in the tip of the V, and the lower viscosity suspensoid of alumina in alcohol is better from this point of view.

Insulated Support Coating

In battery valves, the filament is often located at points along its length by being pulled against a support from the control grid or other electrode. This increases the natural frequency of vibration of the filament and reduces microphony very considerably. It is essential that these supports are covered with an insulated layer and electrophoresis is the best way of accomplishing this. The supports are usually of 0·1mm diameter molybdenum wire with one end bent to the desired shape and coated with the insulator, and the other end attached to the grid side rod. To coat the supports a large number are fixed to a thick wire to form a comb. The tips of the comb are then immersed in the coating bath and the voltage applied for a few seconds and the wires with coated tips then withdrawn. They are subsequently sintered in hydrogen to give a strong insulating layer.

An alumina heater coating suspension can be used but a coating with lower sintering temperature is suitable, as the temperature of operation in the valve is quite low and such mixtures give adequate insulation. Such a suspensoid consists of alumina and clay suspended in a dilute aqueous solution of sodium silicate and only a few volts need be applied to the bath for coating at a suitable rate.

Coating is performed on a single head machine shown in Fig. 6. The "comb" is fixed in a clip and a cam operated dipper raises the coating from the main container till the comb dips in the surface to the right depth. The voltage is then applied for the appropriate time and the dipper then lowered. The coating is stirred continuously in the main container by rotation at about 60 rev/min and inclined vanes are attached to the outside of the dipper, to assist the mixing.

Other Uses of Electrophoresis

Electrophoresis can be used in other ways in valve making. Zirconium metal powder is applied to the anodes

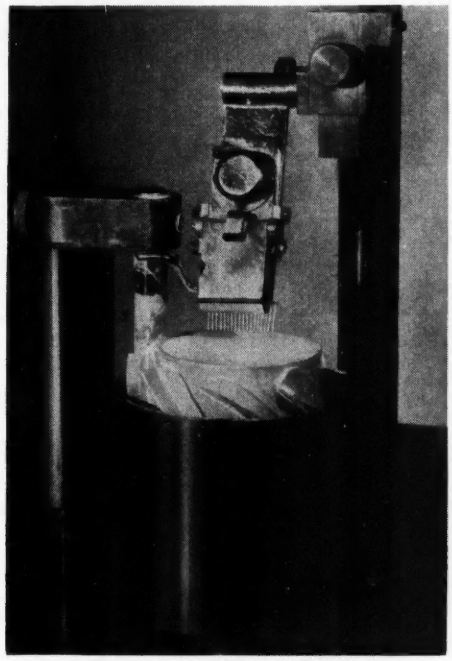

Fig. 6. Comb-type coating plant

of transmitting valves to act as a getter, and this is sometimes applied by electrophoresis in preference to painting. Grids which have to dissipate a lot of heat can be coated with a carbon layer by electrophoresis to increase their thermal radiation and thus reduce the temperature.

Conclusion

It is hoped that this outline will have demonstrated how a relatively obscure branch of physical chemistry has become of use to the valve engineer to enable him to make valves more reliably and efficiently. The process will no doubt continue to be used in these and other ways in the industry.

Acknowledgments

In conclusion the authors desire to tender their acknowledgments to the M.-O. Valve Co Ltd, on whose behalf the work described in the article was carried out.

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Arc Voltage Drop Measurements on Grid-controlled Mercury Rectifiers

By T. H. Barton*, B.Eng., Ph.D., and F. A. Benson* M.Eng., Ph.D., A.M.I.E.E.

The Ratcliffe-Isaacs oscillograph method[4] for measuring arc voltage drop in mercury rectifiers gives erroneous results. The circuit can be modified, however, to produce correct readings as shown and discussed here.

Some comments are made about measurements, with the new instrument, on a grid-controlled rectifier. For this purpose a further circuit addition is desirable.

VARIOUS methods have been suggested for measuring the arc voltage drop in mercury-arc rectifiers[1-4]. Reference has been made to a number of these by Ratcliffe and Isaacs[4] who have also presented a novel oscillograph method. The authors recently constructed the instrument designed by Ratcliffe and Isaacs to carry out some measurements on a new rectifier and found that it gave erroneous results. This led to an essential modification of the circuit which is given and discussed in this article.

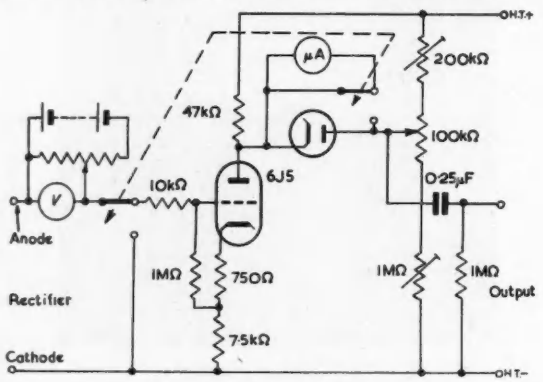

Fig. 1. Original circuit of Ratcliffe and Isaacs

Some experience with the use of the modified instrument for measuring arc voltage drop in grid-controlled rectifiers with various angles of delay is described and another addition to the circuit is suggested.

The circuit given by Ratcliffe and Isaacs is reproduced in Fig. 1. The voltage drop to be measured is fed to a single-stage feedback amplifier and dispenses with the need for a double-beam oscillograph which is essential with an earlier method of a similar type[3]. The circuit provides its own zero-level indication in the manner described below. The output is taken from the anode of the amplifier through a diode and capacitor to the deflecting plates of an oscillograph. The diode is intended to act as a switch allowing the anode-voltage variations of the amplifier to be transmitted to the oscillograph only when the anode voltage lies below the potential of the potentiometer slider. To set up the circuit for measurements the potentiometer slider is simply adjusted, with the input terminals short-circuited, until there is no potential difference across the diode. This is done by connecting a microammeter across the diode as shown in Fig. 1. Having made this adjustment the short-circuit at the input is removed, the meter is taken from across the diode and the arc voltage drop to be measured is applied to the input terminals. If the input voltage applied to the amplifier is at zero level it has been assumed that the diode is on the point of non-conduction. Then, when the rectifier anode becomes positive with respect to the cathode a negative-going wave appears at the amplifier anode and is transmitted through the diode to the oscillograph. For the period when the input voltage is reversed the diode becomes non-conducting and the waveform is not applied to the oscillograph. Thus, Ratcliffe and Isaacs have taken the zero input level to represent the demarcation between the points where a signal is, and is not, transmitted to the oscillograph.

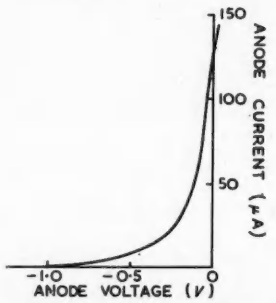

Fig. 2. Typical characteristic for diode type EA50

When the circuit was used recently by the authors a figure of about 26V was obtained for the arc-voltage drop of the particular rectifier being examined and the oscillograms appeared to be satisfactory. The result was considerably in excess of the expected value of 18V, however, and checks by other methods confirmed that the instrument was reading much too high. An investigation was, therefore, carried out to find the reasons for the incorrect readings.

The trouble was due to the fact that the diode used by the authors (type EA50) conducts before the amplifier anode voltage goes negative as can be seen from the typical characteristics of Fig. 2. This is probably true of most other diodes, if not all. It should be noted that Ratcliffe and Isaacs do not state the type of diode which they used and, therefore, presumably regard the choice as unimportant. It will be realized that, in setting up the instrument for measurements, the diode still conducts even though the microammeter gives zero deflexion. By placing the microammeter in series with the diode, however, and then adjusting the potentiometer slider until the meter deflexion is zero, the correct zero-level indication is obtained. It was thought that the high impedance of the diode near the point of cut-off might result in distortion so the modified instrument was calibrated by applying a

* *The University of Sheffield*

sine-wave alternating voltage of accurately-known peak value to the input terminals. The circuit behaved perfectly linearly as can be seen from the calibration curve of Fig. 3.

The following calculations have been made to determine the magnitude of the error produced by the original circuit. They will help to emphasize the reason for the error.

Consider the setting-up position of the instrument. The grid of the amplifier is at zero potential and the cathode

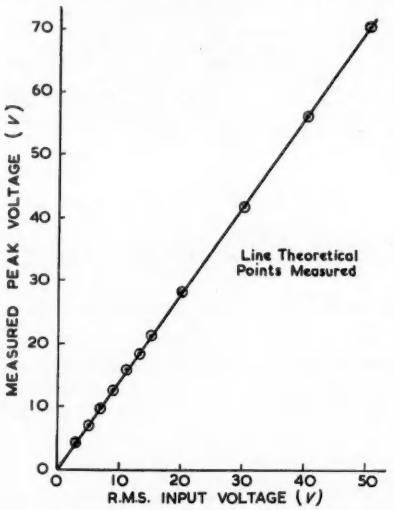

Fig. 3. Calibration curve showing accuracy and linearity of the modified circuit

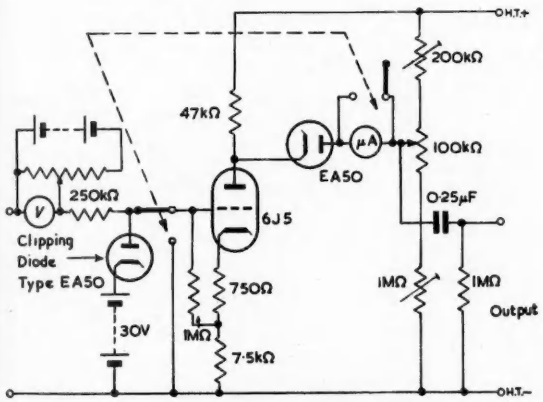

Fig. 4. Modified circuit with clamping diode

is somewhat positive due to the cathode-bias resistor. Adjustment of the potentiometer tapping to give zero current through the microammeter ensures that the tapping is at the same potential as the amplifier anode. The diode shunts the microammeter and in the authors' case passes a current of 120μA for the "set-up" condition. The diode can be cut-off only by driving its cathode about 1V positive with respect to its anode. This point of cut-off fixes the zero level on the oscillograph. It is evident from Fig. 1 that cutting off the diode results in a rise of its anode potential of about 24V which is the change in the drop of voltage across the top section of the potentiometer for a current change of 120μA. To achieve cut-off in the diode, therefore, the anode voltage of the amplifier must rise by about 25V (i.e., 24 + 1). With a gain of, say, 3·5 this corresponds to an error in zero level of 25/3·5 i.e. 7V. It would appear that this error can be reduced by lowering the resistance of the potentiometer but it should be noted that, when the diode is conducting, the top section of the potentiometer shunts the amplifier anode load thus affect-

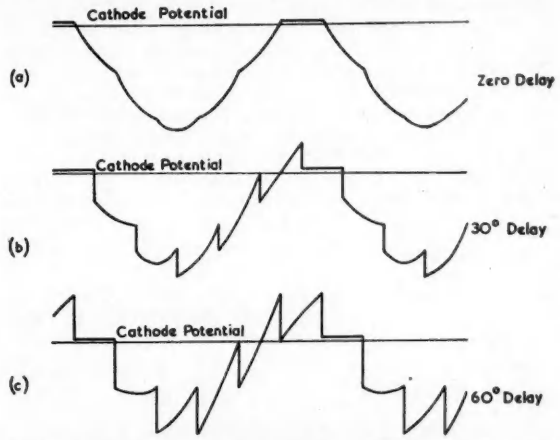

Fig. 5. Anode-cathode voltage waveforms for a six-phase grid-controlled rectifier with angles of delay of zero, 30° and 60°

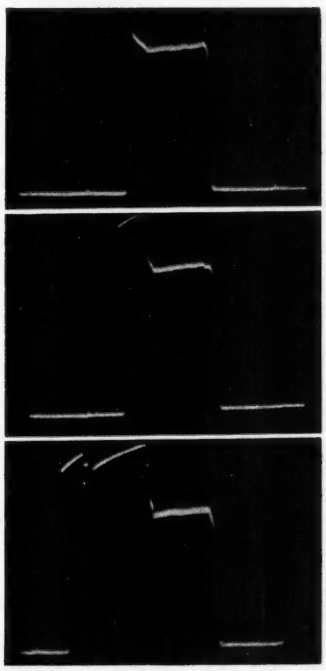

Fig. 6. Oscillograms of arc voltage of simple six-phase grid-controlled rectifier for angles of delay of zero, 30° and 60°

ing the gain. In fact, it is found with the circuit constants of Fig. 1, and with the diode type EA50, that the minimum error is about 2·3V and is obtained with a potentiometer top section of 17·5kΩ.

In the case of a grid-controlled rectifier it is convenient to introduce a clipping circuit as shown in Fig. 4 to prevent large positive voltages being fed on to the grid of the amplifier. Illustrations of the anode-cathode voltage

of a 6-phase grid-controlled rectifier when operating with angles of delay of 0, 30° and 60° are given in Fig. 5. The peak-inverse voltage is approximately twice the maximum output voltage. Thus, for a 250V rectifier the peak-inverse voltage is about 500V. Furthermore, positive voltages up to 400V and lasting for as long as half a cycle occur as the angle of delay is increased from zero to 90° i.e. for rectifier output voltages from maximum down to zero. When the rectifier is running as an invertor the magnitude and duration of the positive voltage are still further increased. These large positive voltages do not appear to damage the original instrument but it is probably inadvisable to operate under these conditions for long periods. In addition, the appearance of the oscillograph trace is improved by the presence of the clipping diode as can be seen from the typical oscillograms of Fig. 6. The bias voltage of the clipping diode can be adjusted readily so as to allow the arc voltage to be passed but not much of the peak voltage.

Acknowledgment

The work recorded in this article was carried out in the Department of Electrical Engineering at the University of Sheffield. The authors wish to thank Mr. O. I. Butler, M.Sc., M.I.E.E., for the facilities placed at their disposal.

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The Correction of Q Meter Readings

By J. P. Newsome*, B.Sc., A.M.I.E.E.

When high value, direct Q factor measurements are made using the "Circuit Magnification Meter" or "Q Meter", significant errors may be introduced by the residual impedances in the measuring circuit. The article describes a rapid method of correcting the indicated Q factor by the use of correction factors.

FOR an increasing volume of high frequency work, Q factor measurements are required to within an accuracy of ± 2 to 5 per cent. The majority of these measurements are carried out on a form of "circuit magnification meter" (or "Q meter") rather than a bridge circuit for reasons of simplicity and speed.

Large air cored coils and coils using powder or ferrite core materials may exhibit Q factors over the range 200-600 and in measuring such values, the circuit residuals may present an error in a direct Q measurement up to perhaps 20 per cent. A method of correction for the effect of these residual impedances is presented in this article, which makes use of graphed correction factors in Q factor form and which has advantages over a straightforward and rigorous method.

Q Meter Circuit

A familiar form of circuit employs a constant voltage source feeding into a series tuned circuit. The Q factor of the test inductor is read in terms of the voltage input under resonant conditions to a high input impedance valve-voltmeter connected across the tuning capacitor, the test inductor being connected between the high potential ends of the source resistance and tuning capacitor. Details of this test circuit are shown in Fig. 1.

Definition of Q Factor and Equivalent Circuit of Test Inductor

It is not proposed to enter into a discussion of this aspect of the subject. The test inductor will therefore be treated as an effective inductance, L, in series with an effective loss resistance, R. The effective Q factor of the test inductor is then defined as

$$Q = \omega L/R \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

The use of this effective Q factor obviates the necessity to enter into a consideration of the effects of coil self capacitance and coil loss. The subject of Q-factor definition and interpretation is discussed in papers by Welsby[1], Biggs and Houldin[2] and in British Standard 204:1943.

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Analysis of the Test Circuit

To assist in the analysis, the source, consisting of a constant current feeding into a very low impedance, is replaced by an equivalent generator, E_s, and series impedance, Z_s,

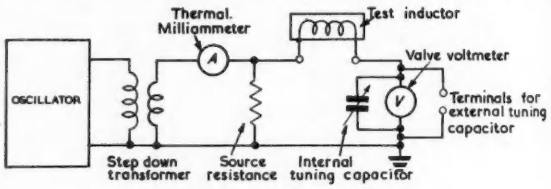

Fig. 1. Practical basic circuit

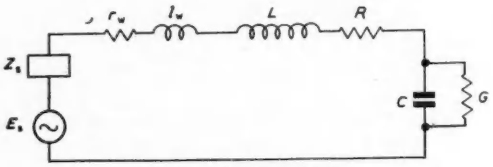

Fig. 2. Analytical circuit

through the application of Thevenin's theorem, where

$$E_s = I_0\sqrt{(r_s^2 + \omega^2 l_s^2)} \quad \ldots\ldots\ldots\ldots \quad (2)$$

and

$$Z_s = r_s + j\omega l_s \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

In practice, $\omega l_s < r_s$, so that E_s is largely independent of frequency.

Referring to the theoretical circuit shown in Fig. 2, the current I is given by

$$I = \frac{E_s}{R + j\omega L + 1/j\omega C + Z_R} \quad \ldots\ldots\ldots \quad (4)$$

where

$$Z_R \text{ (the residual impedance)} = r_s + r_\omega + r_c + j\omega\{l_s + l_\omega\}$$
$$= r_s' + r_c + j\omega l_\omega' \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

putting $r_s + r_\omega = r_s'$ and $l_s + l_\omega = l_\omega'$. Here r_c is the

equivalent series loss resistance of the valve-voltmeter and tuning capacitor conductance, G, and is given by

$$r_c = G/\omega^2C^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

(It is assumed that the ratio $\omega C/G$ is so large that the equivalent series and shunt values of tuning capacitance, C, are in practice identical.) The voltage across the tuning capacitor, V_c is seen to be

$$V_c = \frac{1}{j\omega C} I$$

$$= \frac{E_s}{1 - \omega^2 LC + j\omega C\{R + Z_R\}}$$

$$= \frac{E_s}{1 - \omega^2 LC + j\omega C(R + r_s' + j\omega l_\omega')}$$

$$= \frac{E_s}{1 - \omega^2 C(L + l_\omega') + j\omega C(R + r_s' + r_c)}$$

Then

$$|V_c| = E_s \frac{1}{\sqrt{[(1 - \omega^2 L'C)^2 + \omega^2 C^2 R'^2]}} \quad \ldots\ldots (7)$$

writing $L' = L + l_\omega'$ and $R' = R + r_s + r_c$.

By differentiation of equation (7) with respect to the tuning capacitance, C, and equating to zero to obtain the resonant condition (here defined as $|V_c|_{MAX}$) the following result is obtained:

$$|V_c|_{MAX} = E_s \cdot Q' \cdot \sqrt{(1 + 1/Q'^2)} \quad \ldots\ldots\ldots (8)$$

LIST OF SYMBOLS USED

E_s = equivalent source E.M.F. of measuring circuit. (R.M.S.)
V_c = voltage across tuning capacitor. (R.M.S.)
$V_{c\,MAX}$ = voltage across tuning capacitor (maximum R.M.S.)
I_o = thermal milliammeter current. (R.M.S.)
I = measuring circuit current. (R.M.S.)
C = capacitance of tuning capacitor
G = conductance of valve-voltmeter input circuit and tuning capacitor.
l_s = effective series inductance of source.
l_ω = effective series inductance of wiring of measuring circuit.
L = effective series inductance of test inductor.
L' = total series inductance of measuring circuit.
r_s = effective source resistance.
r_ω = measuring circuit wiring resistance.
R = effective series resistance of test inductor.
R' = total series resistance of measuring circuit.
ω = $2\pi \times$ frequency, f.
Q = effective Q factor of test inductor.
Q′ = effective Q factor of measuring circuit.
Q_I = indicated Q factor.
s, Q_A, Q_{A1}, Q_{A2}, Q_B = correction factors.
Z_s = equivalent source impedance.
Z_R = effective residual impedance of measuring circuit.

which occurs at $\omega^2 = \frac{1}{L'C} \cdot \frac{1}{1 + 1/Q'^2}$ ..... (9)

where $Q' = \omega L'/R'$ and is the effective measuring circuit Q factor.

Assuming Q′ is large compared with unity, equations (8) and (9) simplify to

$$|V_c|_{MAX} = E_s \cdot Q' \quad \ldots\ldots\ldots\ldots\ldots (10)$$

$$\omega^2 = 1/L'C \quad \ldots\ldots\ldots\ldots\ldots (11)$$

(Note that differentiation of equation (7) with respect to frequency gives results differing slightly from those shown in equations (8) and (9), but yields identical simplifications to those shown in equations (10) and (11): differentiation with respect to inductance gives results identical with equations (10) and (11).)

The value of V_c under resonance conditions is then a function of the effective circuit Q factor, Q′, so that the valve-voltmeter may therefore be calibrated in terms of Q′ for a given value of source E.M.F.

It has been hitherto assumed that E_s is a constant for a fixed value of I_o, whereas it will in practice show a small increase with frequency. The instrument is usually calibrated at a low frequency where E_s is a constant, since $\omega l_s \ll r_s$. The source E.M.F., E_s will rise above the low frequency value in the ratio $\sqrt{(1 + \omega^2 l_s^2/r_s^2)}$ at a frequency $\omega/2\pi$: so that if the indicated Q factor is given by Q_I, the effective circuit Q factor will be given by

$$Q' = Q_I/s \quad \ldots\ldots\ldots\ldots\ldots (12)$$

where

$$s = \sqrt{(1 + \omega^2 l_s^2/r_s^2)} \quad \ldots\ldots\ldots\ldots (13)$$

To obtain the required value, Q, from the effective circuit Q factor Q′, the following procedure is adopted:

$$Q' = \frac{\omega L'}{R'} = \frac{\omega(L + l\omega')}{R + r_s' + r_c} = \frac{\omega L}{R + r_s' + r_c} + \frac{\omega l_\omega'}{R + r_s' + r_c}$$

$$\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

$$= \frac{1}{R/(\omega L) + (r_s' + r_c)/(\omega L)} + \frac{\omega l_\omega'}{R'}$$

$$= \frac{1}{1/(Q) + (r'_s + r_c)/(\omega L)} + \frac{\omega l_\omega'}{R'} \quad \ldots\ldots\ldots\ldots (15)$$

The correction terms, which are now in the form of Q factors (i.e. a ratio of reactance to resistance) may be manipulated as follows:

$$\frac{1}{Q_A} = \frac{r_s' + r_c}{\omega L} = \frac{r_s' + G/\omega^2 C^2}{1/\omega C} = r_s' \cdot \omega C + G/\omega C =$$

$$= \frac{1}{Q_{A1}} + \frac{1}{Q_{A2}} \quad \ldots\ldots\ldots\ldots (16)$$

since $\omega L = 1/\omega C$ (very nearly) and $r_c = G/\omega^2 C^2$ (equation (6)).

$$Q_B = \omega l_\omega'/R' = \omega l_\omega'/\omega L'/Q' = Q' \cdot l_\omega'/L' \quad \ldots (17)$$

since $Q' = \omega L'/R'$.

Thus

$$Q' = \frac{1}{1/Q + 1/Q_A} + Q_B$$

or

$$Q = Q' \frac{Q_A}{Q_A - (Q' - Q_B)} - \frac{Q_B \; Q_A}{Q_A - (Q' - Q_B)} \quad \ldots\ldots (18)$$

Usually $Q_B \ll Q_A$ and a further simplification yields

$$Q = Q' \frac{Q_A}{Q_A - Q'} - Q_B \quad \ldots\ldots\ldots\ldots (19)$$

Practical Operation of Correction Procedure

Since low Q factor values (< 10 to 20) are not accurately measurable on most commercial Q meters, the simplification applied in utilizing equation (10) yields an error small compared with the error of the instrument.

For a given instrument the factor s may be plotted against frequency, the factor Q_A against tuning capacitance for different frequencies, the factor Q_B against L' for

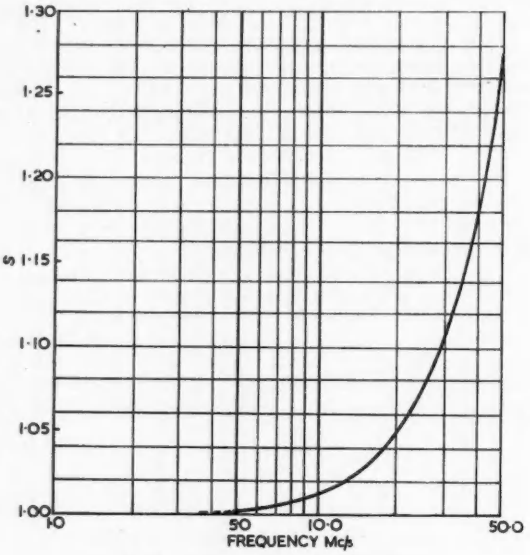

Fig. 3. Correction factor (s)/frequency

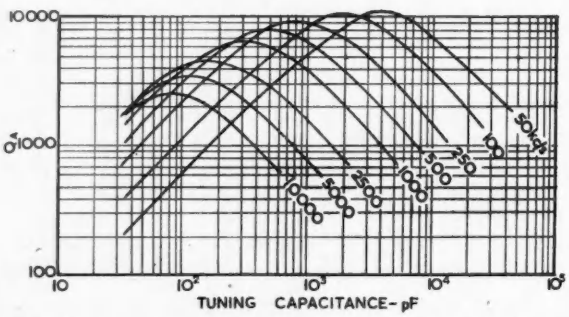

Fig. 4. Correction factor (Q_A)/tuning capacitance for a range of frequencies

different values of Q'. Using these curves, an indicated Q factor may be quickly corrected to give the effective test inductor Q factor. Where the correction factors become relatively large, it may be inferred that a substitution measurement should be used, if possible, rather than a direct measurement.

To demonstrate the operation of the technique, the correction factors are graphed in Figs. 3, 4 and 5 for the Marconi Instruments Ltd, Circuit Magnification Meter type TF329G[3]. For this instrument,

$$r_s = 0{\cdot}04\Omega : l_s \simeq 10^{-4}\mu H : l_\omega \simeq 0{\cdot}05\mu H : G = [5 + 10 f_{Mc/s}] \times 10^{-5}\text{mho} : E_s = 10\text{mV or } 20\text{mV} : V_0 \doteq 0{\cdot}5V$$

This instrument carries an internal tuning capacitor of capacitance range 40 to 480pF and an internal oscillator with frequency coverage 50kc/s to 50Mc/s.

Example 1.

$f = 4\text{Mc/s}$; $C = 298\text{pF}$, $Q_I = 260$.

$$L' = \frac{10^6}{4\pi^2 \times 16 \times 10^{12} \times 298 \times 10^{-12}} = 5{\cdot}32\mu H : s = 1{\cdot}00,$$

$Q_A = 2900$, $Q_B = 2$

$$\therefore Q = \frac{260}{1{\cdot}00} \times \frac{2900}{2900 - 260} - 2 = 284.$$

Example 2.

$f = 100\text{kc/s}$; $C = 150\text{pF}$, $Q_I = 175$.

$$L' = \frac{10^5}{4\pi^2 \times 10^{10} \times 150 \times 10^{-12}} = 16{\cdot}9\text{mH} : s = 1{\cdot}00,$$

$Q_A = 1550$, $Q_B = 0$.

$$\therefore Q = \frac{175}{1{\cdot}00} \times \frac{1550}{1550 - 175} - 0 = 197.$$

NOTE:—Factor s is not usually significant at frequencies <5Mc/s; factor Q_B is not usually significant for a test inductance >50μH.

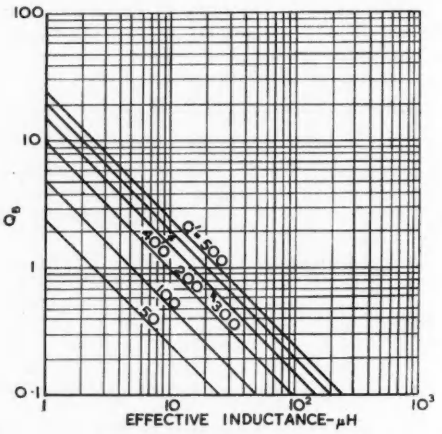

Fig. 5. Correction factor (Q_B)/effective inductance (L') for different values of effective measuring circuit Q factor (Q')

Conclusion

The correction procedure detailed above has two principal advantages over the straightforward and rigorous method:

1. Considerable saving in time, due to a reduction in the number of calculations and manipulations.
2. Simplicity; there being considerably less chance of an arithmetical error occurring in the result, due to elimination of resistance and reactance calculations.

The method may be readily extended to take into account residuals brought into circuit by additional components, such as extra tuning capacitors.

Acknowledgments

The author wishes to thank Professor H. Cotton, M.B.E., D.Sc., for facilities afforded him in connexion with this work.

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3. Measurement by Q Meter (Marconi Instruments Ltd.).

Short News Items

The English Electric Co announce the development of new X-ray apparatus. A chance conversation with a member of the staff of the Stafford General Infirmary has led to the production of what is believed to be the first equipment of its kind in the world for use in X-ray examinations of the brain. Known as angiography of the brain, this examination is one of the most delicate of X-ray operations. It involves injecting the patient with a solution which is opaque to X-rays, thus rendering visible the brain's network of arteries in X-ray photographs. Hitherto the timing of the exposure has had to be done either manually or by the use of cinematography, neither of which had proved satisfactory. It was decided to attempt to produce a new type of timer device to solve the problem. The project was undertaken by the staff of the switchgear development workshop at the English Electric Company's Stafford works, and there the prototype was both designed and built. The resulting equipment, comprising a casette changer, electronic sequence and exposure timer, and a mobile carrier, enables a radiographer to use a sequence of X-ray exposures to pre-determined exposure times and with controlled time delays between exposures.

Marconi's Wireless Telegraph Co have signed a contract with the Egyptian Assistant Air Attache in Britain, acting on behalf of the Egyptian Government, for the supply of navigational radar equipment, radio transmitters, receivers and associated test equipment for use aboard five warships of the Egyptian Navy.

The Plessey Co Ltd announce the appointment of Mr. John Hilton and Mr. C. D. H. Webb as executive directors of the company.

Mr. C. E. T. Cridland has been elected president of the Scientific Instrument Manufacturers' Association. He is chairman and managing director of a group of companies including Aldis Brothers Ltd of Birmingham, makers of the Aldis signalling lamp used by airfields.

Truvox Ltd announce that Mr. K. Short has been appointed a director of the company. He previously held the post of chief engineer.

Mr. Jack Palmer has been appointed general manager of the W. H. Sanders (Electronics) Ltd new factory at Stevenage. In his new position he will be responsible to the directors for all aspects of the operation of this factory.

The Eighth Annual Congress and Festival of Scientific Films of the International Scientific Film Association will take place from 2-12 November at the University City and National Research Council, Rome. The Scientific Film Association, as the member organization for Great Britain of the ISFA, is organizing British participation in the Congress. Inquiries should be sent to the Scientific Film Association, 164 Shaftesbury Avenue, London, W.C.2.

The Leipzig Fair will be held from 5 to 15 September, with sections for capital and consumer goods. 9 000 exhibitors from over 30 countries are taking part.

Courses. Applications are invited by the Atomic Energy Research Establishment, Harwell, from physicists and electronic engineers holding a degree or equivalent qualification, who wish to attend the ninth electronics course. The course covers the design, use and maintenance of electronic instruments used in nuclear physics, radiochemistry, and in work with radioisotopes. The course, to be held at the Isotope School, Harwell, will be from 1-5 November. The fee is 12 gns and application forms can be obtained from the Electronics Division, A.E.R.E., Harwell, Didcot, Berks.

The South East London Technical College announce new courses of lectures for the 1954-55 session. Full details may be obtained from the Head of the Electrical Engineering and Applied Physics Department, South East London Technical College, Lewisham Way, London, S.E.4.

Details of evening courses at the Polytechnic in telecommunications, including television and radio servicing, are available from the Head of the Electrical Engineering Department, The Polytechnic, 309 Regent Street, London, W.1.

The Air Ministry announce that all seven R.A.F. officers who have recently completed the one-year Southampton University course in electronics at post graduate level have received diplomas, two of them with First Class Honours. The course is recognized as one of the most advanced of its kind, normal condition of entry being a good honours degree in Engineering or in Physics.

Communications Systems Ltd have installed a new automatic telephone exchange, the most modern available, at Withington Hospital, Manchester. The new exchange, which is now in operation, provides for twelve exchange lines and 200 extensions throughout the hospital.

Enfield Cables Ltd. announce that Mr. Rex Bate has been appointed sales director of the company.

PUBLICATIONS RECEIVED

REPORTS ON PROGRESS IN PHYSICS VOL. XVII (1954). These reports are under the general supervision of the Papers Committee of the Physical Society. The reports published in this volume are being issued also as individual articles, at prices depending on length. The Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7 Price to Non-Fellows 50s. Price to Fellows 27s. 6d.

A BIBLIOGRAPHY OF COLOUR TELEVISION has been published by the Television Society. In 1953 a Bibliography of Colour Television was prepared by the Librarian of Ultra Electric Ltd, and copies circulated among members of the radio industry. The Television Society considered that its usefulness would be increased by a wider circulation and have undertaken its publication in printed form. The Television Society, 164 Shaftesbury Avenue, London, W.C.2. Price 2s.

INTERNATIONAL AERADIO LTD is a brochure, designed and produced by Newman Neame Ltd, which gives an account of the work of this company, carried out at some 80 locations under more than 30 different administrations. The extent of these activities and the use to which the company's unique experience has been put are briefly described. International Aeradio Ltd, Aeradio House, 40 Park Street, London, W.1.

RCA ATOMIC BATTERY gives the brief history of a new method which makes it possible to convert atomic energy directly and simply into small but usable quantities of electrical energy sufficient to operate a transistor. This was announced in January this year by the Chairman of the Board of the Radio Corporation of America. RCA Photophone Limited, 36 Woodstock Grove, London, W.12.

TV TROUBLESHOOTING AND REPAIR GUIDEBOOK Volume 2, is a well-illustrated book of assistance to those interested in American methods of troubleshooting. John F. Rider Publisher, Inc., New York. Price $3.30.

CAREERS IN RADIO AND ELECTRONICS is a booklet which shows diagramatically the trainee's progress from school to the highest engineering and executive posts in the industry. For the professional engineering grade alone the industry, it is stated, requires 1 000 recruits every year and the number of technicians required is very much greater. The booklet is available direct from the Secretary, The Radio Industry Council, 59 Russell Square, London, W.C.1.

CATALOGUE OF MICROWAVE INSTRUMENTS. The instruments described in this catalogue are grouped in three categories according to their application in the 3cm band, 10cm band, or in more than one band. Together with the additions which are made from time to time, there is sufficient variety to meet a great many requirements. Scanners Ltd, Gateshead 10.

THE QUARTERLY JOURNAL OF MECHANICS AND APPLIED MATHEMATICS, VOL. VII, PART 2, JUNE 1954 contains various papers of the usual high standard of interest. Oxford University Press, Amen House, London, E.C.4. Price 15s. (Annual subscription for four numbers 50s. post free).

GECALLOY LOW LOSS CORES AND MICROPOWDER MAGNETS is a booklet which describes the production and use of various kinds of Gecalloy material and compares these with other magnetic materials. Salford Electrical Instruments Ltd., Peel Works, Silk Street, Salford 3, Lancs.

LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

A Pulse Frequency Ratiometer

DEAR SIR,—Mr. J. L. Douce's elegant Analogue Divider in the April issue suggests a simple form of instrument for measuring the ratio of two pulse frequencies. Either or both of the pulse trains may be random. The principle is to width-modulate the "numerator" pulse train at constant amplitude by a function which varies inversely as the "denominator" pulse frequency; this may be accomplished by Mr. Douce's basic circuit (Fig. 1) when the voltage applied to the integrating resistor is supplied from a ratemeter tank circuit fed by the "denominator" pulse train.

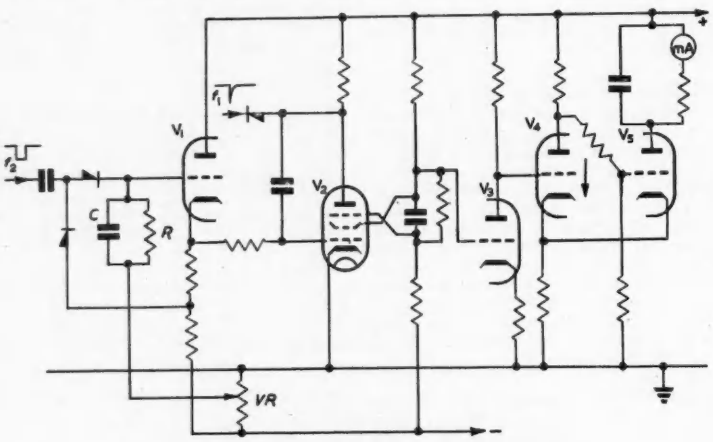


Fig. 1. Simplified circuit of pulse-frequency ratiometer

In the simplified circuit diagram shown here CR is the ratemeter tank and V_1 is a cathode-follower which linearizes the voltage-frequency relationship and supplies the voltage to be integrated by the Miller transitron, V_2. V_1 in effect forms part of a diode pump linear step circuit (e.g. M.I.T. "Waveforms," p. 617) with a leak across the storage capacitor, and with one diode anode tapped down the cathode resistor in order to prevent simultaneous conduction of the two diodes. The potentiometer VR, enables a "background" correction to be applied to f_2 if necessary. V_2 is triggered by the "numerator" pulse train (f_1). V_3 inverts the positive-going screen rectangle and operates a Schmitt trigger circuit (V_{4-5}) in which V_4 is normally conducting. The reading of the milliameter in the anode circuit of V_5 is proportional to f_1/f_2 and is independent of the precise value of the amplitude of the screen pulses from V_2.

If the f_1 pulse train is random there is a "dead time" effect depending on the value of the frequency ratio. The mean current through V_5 is $If_1'W$ where I is the amplitude (constant), W is the width in seconds and $f_1'=f_1/(1+f_1W)$. Hence if $W=T/f_2$ the mean current is $IT(f_1/f_2)/[1+Tf_1/f_2]$. Thus for a linear law with random pulses the width-modulation constant, T, should be suitably small.

Yours faithfully,

B. D. CORBETT,

Department of Clinical Research,
University College Hospital
Medical School.

The Author replies:

DEAR SIR,—I am grateful to Mr. Corbett for pointing out this interesting extension of the principle of the analogue divider.

The comparison of two frequencies is a notoriously difficult operation, and such a simple and direct method has much to commend it.

Yours faithfully,

JOHN L. DOUCE,

Electrical Engineering Laboratories,
The University,
Manchester.

The Measurement of Very Small Direct Currents

DEAR SIR,—In Mr. M. W. Jervis' letter in the May issue, page 219, reference is made to the use of barium-strontium titanate ceramics in dielectric amplifiers, and to the rather large temperature effects in these materials.

In this connexion, it may be of interest that we have developed a new range of ceramic compositions having a relatively high order of non-linearity, coupled however with low temperature variations of the permittivity, for this class of material.

In modulator elements made up from these ceramics, variations in capacitance of the order of 50 per cent are obtained by the application of about 170V D.C., the maximum temperature variations in permittivity between 20° and 85°C., on the other hand, being only about 15 per cent.

A further point of interest is that the ratio of the differential permittivity at the coercive field to that at saturation, derived from the hysteresis loops, is higher in these materials than for barium-strontium titanate; this figure is moreover maintained substantially over the temperature range of −60°C to +80°C. The Curie points of the materials are above 100°C, and the loss tangents over the working temperature region of the order of 0·02, measured at 1kc/s.

Yours faithfully,

G. V. PLANER,

G. V. Planer, Ltd,
Feltham, Mddx.

Microphony in Voltage Reference Tubes

DEAR SIR,—The letter from Messrs. Aitchison and Murray which appeared in your May issue was of considerable interest as we have recently had occasion to make a similar series of measurements with the 85A2 reference tube.

The 85A2 being of miniature construction is somewhat less liable to microphony than the 85A1 which was the subject of the tests mentioned. The cathode is in the form of a three-quarter cylinder supported by three spot welded wires spaced at approximately 120°, these connecting directly to the pins. The anode, being a central thick wire, is spot welded to the centre of a second thick wire across the two anode pins in the base. Although neither electrode is supported at its upper end, the low moment of inertia coupled with the high value of stiffness of such a small system ensures that any excursion would be of a small amplitude.

It is believed that the use of mica supports in high stability reference tubes is to be avoided since it is virtually impossible to obtain gas-free mica. Under conditions of vibration the gas tends to be released thus causing a variation in the characteristics of the neon.

The D.C. level of the 85A2 does not change when impact tested, once the initial transient has died away, which is in agreement with the results of Messrs. Aitchison and Murray. In fact, four successive decelerations of 100g produced no measurable change in burning voltage in a mixed batch of 12 neons some of which were aged for periods up to 300 hours, others being as received from the manufacturers.

The equivalent figures for Table 1 for the 85A2 are as follows:—

Initial peak of transient for an impulse of 1ft lb/sec	= 4·0mV
Time to decay to $1/e$ of inital value	= 6·6msec
Approximate fundamental frequency	= 1 200c/s

The twelve neons employed in the impact test were vibrated at 50c/s at 2g and 20g. In neither case, however, could any induced ripple voltage be detected. The maximum ripple voltage which could be resolved with the oscilloscope employed was in the region of 1mV peak-to-peak.

In order to investigate the rather marked difference in performance between the 85A2 and the QS83/3 a number of the latter were subjected to the same impact as specified in Table I. Although the fundamental frequency and time-constant of the resultant vibration were the same as recorded in the table, a mean value of 3·7mV was recorded for the initial peak of transient.

Although mechanical tests of valves are very difficult to duplicate exactly and Messrs. Aitchison and Murray may well have applied their impact in a different manner, it is none the less remarkable that they have obtained results that differ by an order from those measured in our own laboratory. Indeed our experiments would appear to indicate that on the grounds of transient voltage peak produced by a given impact there is very little to choose between the 85A2 and the QS83/3.

Yours faithfully,

H. J. GORHAM,

Servo Systems Design Department,
de Havilland Propellers Ltd.

In reply:

DEAR SIR,—The difference between our results and those of Mr. Gorham is probably due to the fact that in our measurements the impact was applied to the side of a small U-shaped sub-chassis on which the two valves were mounted, and not to the reference valve itself. We were mainly interested in a comparison of the two types of reference valve we had in hand (the 85A1 and the QS83/3), and not necessarily in their absolute values, as we found that measurements on a high stability regulated supply were being affected by microphony, which we were surprised to find originated in the reference valve.

We should be interested to know of any experimental confirmation of the expected disadvantages of a reference tube construction involving mica supports. The individual drift characteristics we have measured on a small number of valves show such large differences for reference valves of the same type that general comparisons between types are not possible.

Yours faithfully,

R. E. AITCHISON,

Senior Lecturer in Communication Engineering.

C. T. MURRAY,

Lecturer in Electrical Engineering,

The University of Sydney.

A Negative Supply for D.C. Amplifiers

DEAR SIR,—The conventional resistance-coupled D.C. amplifier requires a negative bias supply of the same order of voltage as the positive anode supply, as can be seen from Fig. 1. The fraction of the signal voltage from the anode of V_1 which is applied to the grid of V_2 is $R_a/(R_1+R_2)$. But neglecting the small negative bias on the grid of V_2, the potential difference across R_1 must equal v_a and that across R_2 equals v_b, so that $(R_1/R_1+R_2) = v_b/(v_a+v_b)$ and efficient signal transfer requires v_b considerably greater than v_a; and a suitable value is about equal to the positive rail voltage which is several times the voltage on the actual valve anode. If the bias supply is 300 volts and the grid-leak 1MΩ, the current drawn from the negative rail is only 0·3 mA per stage, and the total is less than that demanded from the positive rail, much less if an output stage of appreciable power is included; yet conventional design requires the complete duplication of the power supply, including mains transformer with H.T. secondary and heater windings, which seems extravagant.

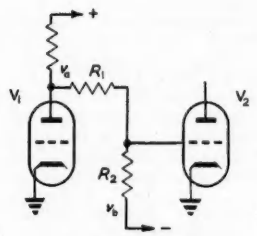


Fig. 1. Conventional arrangement of D.C. amplifier

But for small currents a negative supply can be provided without duplicating the transformer by using a capacitively coupled shunt-diode rectifier fed from one end of the transformer used for the positive supply, as shown in Fig. 2. Since negative output is obtained from the anode of a diode, the cathode of the rectifier used for negative supply will be connected to earth and its heater can be fed from the winding used to supply the heaters of the amplifying valves. In the model built by the author a 6X5 rectifier was used because of its low-current 6·3 volt heater, and the supply was smoothed by an inductance-capacitance filter and stabilized with a multi-gap gas-discharge tube (Osram STV 280/40). But an electronic stabilizer could be used for currents of the order of 15mA which were catered for by this installation. For smaller currents one could use a series combination of low-current neon tubes for stabilization, and perhaps a miniature type of rectifying valve.

The shunt-diode rectifier has the disadvantage of a larger ripple voltage than the series-diode circuit, because the anode potential of the shunt diode falls practically to zero when the supply reaches peak positive and the diode conducts. It is therefore very desirable to use a choke as the first filtering element, but for small currents this need not be bulky, and resistance-capacitance filtering can be substituted with small currents if there is adequate surplus voltage.

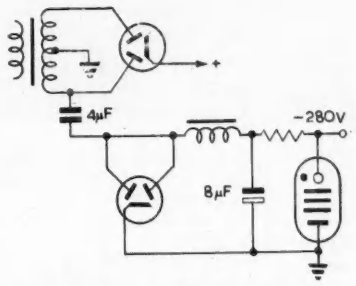


Fig. 2. The stabilized negative supply

Since the anode potential of the diode approaches the cathode potential at the most positive part of the supply cycle, the peak inverse voltage is a trifle over the peak-to-peak voltage of the supply. Another incidental point is that the negative rectifier draws current from the transformer half-secondary when the positive rectifier is not drawing current; and since the copper loss is proportional to the square of the current, the addition of the negative rectifier adds less to the secondary copper loss than would an equal addition to the current drawn from the positive rail.

Yours faithfully,

D. A. BELL,

Electrical Engineering Department,
University of Birmingham.

Meetings This Month

The British Institution of Radio Engineers are holding a meeting on 29 September at 6.30 p.m. at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1. Dr. A. E. Cutler will speak on "Computing Circuits in Flight Simulators".

The British Sound Recording Association's presidential address will be given on 24 September at 7 p.m. at the Royal Society of Arts, John Adam Street, London, W.C.2.

The Physical Society's 38th Guthrie Lecture, which was to have been held on 26 March last, and had to be cancelled at the last moment owing to illness of the lecturer, will be delivered on 24 September, at 5 p.m. in the Lecture Theatre, The Science Museum, Exhibition Road, London, S.W.7. The lecturer, Sir Geoffrey Taylor, will speak on "Diffusion and Mass Transport in Tubes". Non members will be welcome to attend this meeting.

ELECTRONIC EQUIPMENT

A description, compiled from information supplied by the manufacturers, of new components, accessories and test instruments.

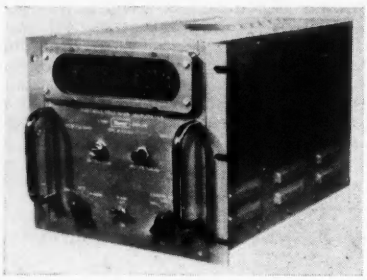
Electronic Tachometer

(Illustrated below)

THIS electronic engine speed indicator enables a result with an accuracy better than 0·1 per cent to be obtained in a timing interval of one to four seconds.

The rotary motion of the shaft must first be converted to electrical pulses and this can be done in a variety of ways, as for instance, the use of a photo-electric device.

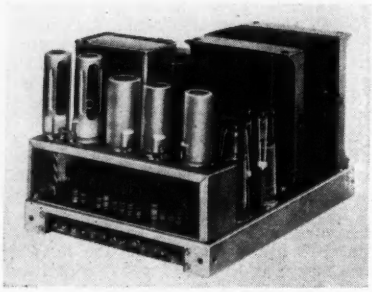
The instrument counts the number of pulses generated in a period of one, two or four seconds. These periods are timed by a 4kc/s crystal oscillator accurate to 0·005 per cent, the output frequency of which is divided by 4 000, with the aid of two Eccles-Jordan scale-of-two counters and three Dekatrons, to produce a 1c/s pulse. This triggers a gating circuit interposed



between the incoming signal and the counting unit, consisting of four more Dekatrons behind the front panel. The gating circuit remains open for one second, after which it is closed by the next pulse derived from the crystal. The total count then remains on display for approximately 0·8sec, when a clearing relay returns the Dekatrons to zero in readiness for the next count. Alternatively, the instrument may be operated manually by means of a push-button. When this is employed one count only is registered and the final count is displayed until the button is again operated. The operation of the counting unit can be checked by feeding a 2kc/s signal from the output of the first Eccles-Jordan scale-of-two counter to the input terminal by means of a switch.

The limit of accuracy is determined by the tolerance of the crystal (0·005 per cent), and by the integral count method employed. Input frequencies with a minimum amplitude of 100mV between 100c/s and 3 000c/s can be determined to the nearest 1 in 1 second.

The Plessey Co., Ltd,
Ilford, Essex.



Stabilized Power Unit

(Illustrated above)

THIS new Solartron regulated power supply type SRS.155 is a development of the model SRS.154 high stability unit. The new instrument, however, provides an output of 250V positive or negative at currents from 10 to 100mA. The stabilization ratio is better than 500:1, and the source impedance less than 0·05Ω. At the full output load of 100mA the total ripple and noise content is less than 100μV, The unit is expressly designed for incorporation into equipments, or for use with experimental circuits in the laboratory.

Solartron Electronic Group Ltd,
Solartron Works,
Queen's Road,
Thames Ditton, Surrey.

Transformer Oil

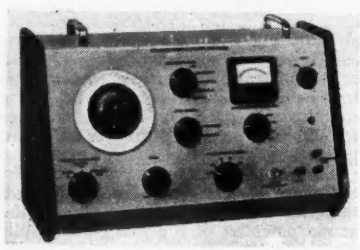
A NEW passivated transformer oil has recently been announced by the Manchester Oil Refinery. It is claimed to have a number of advantages over the oils normally used in transformers and capacitors. It has no tendency to dissolve copper or iron, while if soluble copper compounds are accidentally introduced into the oil they are rendered harmless. An anti-oxidant has also been added to the oil to extend its life.

The Manchester Oil Refinery Ltd,
Twinning Road,
Trafford Park,
Manchester, 17.

A.F. Oscillators

(Illustrated below)

TWO audio frequency oscillators of 0·66W and 5W output are now



included in the range of "Hifi" instruments. These are known as the types HO.50 and HO.500 and cover the frequency range 20c/s to 20kc/s. Alternative models types HO.50A and HO.500A, with a frequency range of 20c/s to 40kc/s, are also available.

The stated performance is; hum level, −60db at maximum output; distortion, less than 1 per cent at maximum output; frequency response, ±0·5db overall when correctly loaded.

Hifi Ltd,
Derry Works,
Derry Street,
Brierley Hill, Staffs.

Cathode-ray Oscilloscope

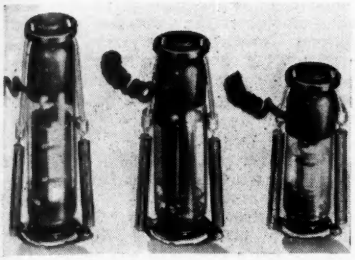
(Illustrated above)

THE miniature oscilloscope model 2300 manufactured by Industrial Electronics uses a 2½in C.R.T., and has outside dimensions of 4½in by 7½in by 7½in.

Direct coupled push-pull vertical and horizontal amplifiers are incorporated. The Y amplifier is controlled by a two position switch providing sensitivities of 50mV/cm from D.C. to 100kc/s and 500mV/cm from 20c/s to 3Mc/s; a continuously variable gain control is fitted; a frequency compensated attenuator is also incorporated. The X amplifier has a maximum sensitivity of 70mV/cm from D.C. to 100kc/s. The time-base frequency is variable from 7c/s to 50kc/s in five ranges; sweep expansion up to five screen diameters is possible.

U.K. Distributors

G. A. Stanley Palmer,
Maxwell House,
Arundel Street,
London, W.C.2.



Valve Top Cap Connectors and Retainers

(Illustrated above)

THE latest additions to the range of Electrothermal radio components are the connecting clip cat. No. TC/4 for use with B7G and B9A based valves, complete with retainer cat. Nos. VRK. 156, 157 and 158.

The clip is moulded from a special heat resistant, non-tracking material and designed for top cap connexions for B7G and B9A valves. It provides an efficient contact, and when used with the appropriate valve retainer, the valve, with the clip, will be held in position under the worst conditions of vibration and shock in mobile, portable and transportable electronic equipment. Three sizes of valve retainer are available to fit all bulb lengths in common use.

Electrothermal Engineering Ltd., 270 Neville Road, London, E.7.

L.E.S. Lampholders

A RANGE of Lilliput Edison Screw pilot lampholders with a variety of fixing arrangements is now being produced by Bulgin. These lampholders, which are considerably smaller than the better known M.E.S. size, are manufactured to Section E.6 of B.S.98; the outside diameter of the bulb holder being approximately ¼in.

A. F. Bulgin & Co., Ltd, Bye Pass Road, Barking, Essex.

L.E.S. Pilot Bulbs

THE Vitality range of bulbs now includes L.E.S. types having bulb diameters of 5·5mm and 7·5mm. They are available in a wide range of power ratings from 1·5V 0·3A to 28V 0·04A.

Vitality Bulbs Ltd, Neville House, Neville Place, London, N.22.

Radiation Monitor

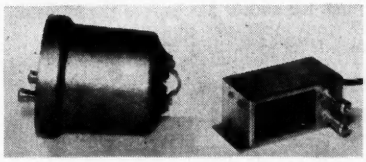
THIS transistor-operated instrument monitors gamma radiation and uses a G5H type Geiger-Muller tube. Power supply is a 30 volt hearing aid battery and consumption is approximately 2mA. The transistor circuit converts the battery voltage to 400V required for the G.M. tube. Indication is by means of headphones, a selection of which is available, ranging from normal headset types to lightweight hearing aid insert type.

Radiometrics Ltd, 44 Tottenham Court Road, London, W.1.

Television Masthead Pre-amplifier

(Illustrated below)

THE Dynatron type 2 masthead pre-amplifier uses a single valve double-triode circuit and gives a gain of 16db. It is intended for use in fringe areas and is readily adjusted to any one of the five channels in Band 1. The input and output impedance is 80Ω. The amplifier is contained in a bell-shaped aluminium casting which is designed to withstand all normal weather conditions. A



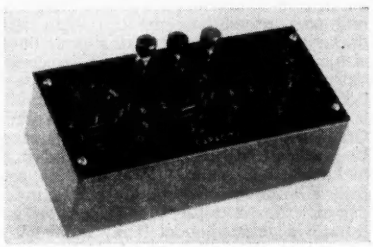
feeder unit is available for supplying the necessary power (at 18V).

Dynatron Radio Ltd, The Firs, Castle Hill, Maidenhead, Berks.

Decade Capacitor Box

(Illustrated below)

THE main feature of this decade capacitor box is the use of a new patented design of eleven-position switch which makes possible a considerable saving in



manufacturing costs. The range of the box is 0·001μF to 1·11μF in 0·001μF steps; the stray capacitance being less than 15pF per decade. The working voltage is 500V D.C., except for the 0·1μF range where it is 350V.

Winston Electronics Ltd, Park Mews, Park Road, Hampton Hill, Middx.

Computor Amplifier

(Illustrated above right)

THIS D.C. amplifier has been designed as a basic building block for analogue computor assemblies. It is arranged to fulfil the dual function of high gain, high accuracy, slow speed computing and higher speed repetitive computing. It performs the operations of summation, differentiation and integration and will provide any desired transfer function

when used in conjunction with suitable computing impedances. The main circuit is drift-corrected and a separate drift-compensated amplifier is provided for sign reversal.

Saunders-Roe Ltd, Osborne, East Cowes, Isle-of-Wight.

Transformers

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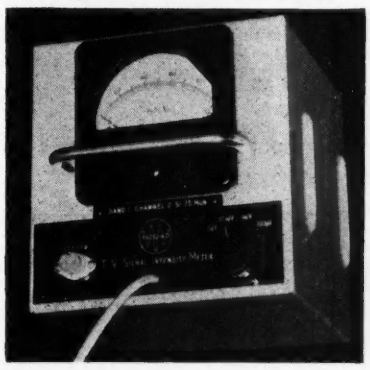

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BOOK REVIEWS

Thermionic Valves
Their Theory and Design

By A. H. W. Beck. 570 pp. Demy 8vo. Cambridge University Press. 1953. Price 60s.

DURING the last twenty years, at irregular intervals, many books on thermionic valves have been published—each in its turn to be welcomed and used by valve engineers and students. The usefulness of any one of these has often been determined by the accuracy with which the author has gauged the needs of his contemporaries in terms of what to include or omit and what to treat fully or cursorily.

The subject matter of Mr. Beck's book seems to us to have been very shrewdly chosen to meet the needs of his present-day readers and, it may be said, to supplement other works written on a more conventional plan. As the author says in his preface, the whole book has been strongly influenced by and biased towards microwave valves, the pre-occupation today of many valve engineers. We hasten to add, however, that the book is very wide in its scope and is not in any sense restricted by this bias.

The three parts into which Mr. Beck divides his book are unequal but balanced in length. The first part, of three chapters, covers such subjects as thermionic, secondary and field emission and fluorescence. Its interest lies not only in the fact that we receive a short but useful summary of up to date emission theories, but also in its derivation of some familiar (and some not so familiar) expressions by the modern quantum treatment. The virtue of this, of course, lies in its consistency—its linking of Dushman's equation, semi-conduction, field emission and so on all within the same framework. Of necessity, not all the discussions can be given in their entirety. This tends to make some of them rather difficult to follow without referring to the original papers. The purpose of this section is to provide a fundamental physical background for the rest of the book.

The second part called "The Mathematical Theory of Electronics" treats of these general properties of valves which are, for the most part, common to all types. Five chapters are required and typical headings are "Electrostatic Fields," "Space-charge Flow" and "Fluctuation Noise." The order of treatment of the different subjects is unusual—electrostatic electron optics follows the treatment of electrostatic fields and precedes that of space charge flow and the diode. This appears to us to be a logical and convenient method and certainly helps reading. The latter chapter will appeal greatly to the valve engineer. The last two chapters on transit time effects and noise respectively provide at once a useful summary of the two subjects and a link with the next chapter.

The third and final part occupies about a half of the whole book and treats of the detailed properties of specific valve classes and types. While a very considerable portion of this part of the book concerns U.H.F. valves such as magnetrons, klystrons and travelling wave tubes, conventional valves for low and medium frequencies are not neglected.

As has been indicated earlier the author appears to have given considerable thought to the order in which he arranges his subject matter. In this section he starts with triodes and multi-electrode valves and gives the various solutions of what might be termed the electrostatic geometrical problem, that is the calculation of amplification factor, current flow and mutual conductance. The chapter on multi-grid valves includes pentodes, tetrodes and multi-electrode frequency changers. The treatment in this chapter is less full than in some other recent books.

He next proceeds to a chapter in which the information is very condensed, on conventional transmitter valves. The high light of this chapter is perhaps the data on grid current and current distribution.

Before presenting the subject of ultra-high frequency triodes, he gives us a chapter on velocity modulated valves so as to present the theory of electron bunching and velocity modulation as early as possible since it applies in some degree to all devices used for U.H.F. amplification or generation. In this chapter he extends it to give the theory of the ordinary amplifier klystron and the reflex klystron.

The very important subject of triodes at ultra-high frequencies is lucidly presented and is largely based on Llewellyn's equations given in Chapter VII on transit time effects. Not the least satisfying aspect of this chapter is its clear statement of the limitations of the theory.

The rather new subject of travelling wave and similar tubes is next dealt with and the author gives us what he calls "the simple theory." This is perhaps a correct description as the author points out that a large signal theory is still lacking.

The magnetron in all its aspects completes the array of U.H.F. devices and the theory is given first neglecting space charge effects and secondly including them. Electron and field interaction are then treated and the chapter ends with a brief reference to the magnetron amplifier.

The book concludes with a brief descriptive chapter on picture convertors and storage tubes. Three appendices bring the reader up to date on emission theories, space-charge waves and noise in travelling wave tubes.

It is particularly to be noted that in all the chapters on U.H.F. devices the question of noise is very meticulously presented. The bibliography appears to be entirely adequate and the presentation, of course, is all that one expects of the Cambridge University Press.

In general terms, it is felt that this

book can be regarded primarily as a reference book rather than as a learning book. This is because many of the mathematical processes are condensed—to varying extents, of course—and, if full detail is required, reference must be made to the original publication. We feel sure, however, that it will take its place on the shelves of all valve engineers among other standard works.

F. M. WALKER.

Einschwingvorgänge Gegenkopplung, Stabilität Theoretische Grundlagen und Anwendungen (Transient Phenomena—Counter-coupling, Stability—Theoretical Principles and Applications)

By Johannes Peters. 181 pp., 130 figs. Medium 8vo. Springer Verlag, Berlin. 1954. Price DM27.

ELECTRONIC engineers able to tackle a German text and having the necessary mathematical and technical background will certainly profit by studying this interesting and thought inspiring book, written by the research director of the Nordwestdeutsche Rundfunk. It is remarkable how more and more disciplines of higher mathematics are nowadays expected to be at the disposal of those who want to get a better insight into the complexities of radio and television theory. A sound knowledge of at least the elements of the theory of functions, of Fourier and Laplace transforms, of Dirac distribution, of convolutions, of matrix algebra and of the theories of quadrupoles and loci is presupposed. This indicates the necessity of acquiring a sound knowledge of pure mathematics at least for those future research workers who will be called upon to deal with the theoretical aspects of the art. Also required for the understanding of the book is a familiarity with the principle of the valves and their characteristics and with the elements of filter theory.

When about 45 years ago the first books appeared about transient phenomena, for instance that of Steinmetz, nothing was known about electronic valves and comparatively little about modern methods of network analysis. Steinmetz dealt mainly with problems of power engineering. His mathematical tools were of a simpler type but rather cumbersome in their application. The present author was led to his investigations by trying to find the conditions under which counter-coupled amplifiers show stability. But the subject matter grew under his hands and this problem is now dealt with mainly in the fourth chapter of the book. A brief summary of the main contents of the book will now be given.

In the first chapter general static and dynamic properties of linear transmission systems are discussed. Definitions are given for complex amplitude, complex transmission factor, complex propagation constant, complex frequency, allpasses and allpass-free systems. The application of the theory of functions, particularly of Cauchy integrals and of Fourier and Laplace transforms are discussed and analogies are shown with potential theory. The part played by zeros, poles and residues is explained. The connexions between carrier frequency systems and I.F. systems are shown.

The second chapter deals with transmission factors for passive and active systems. Matrix algebra and transforms are used in dealing with network analysis and the transmission factors of systems containing valves, i.e. active systems, are briefly discussed.

The third chapter is devoted to questions of stability, stability criteria and stabilization. The mathematical conditions of stability are explained algebraically and by methods of the theory of functions. Hurwitz's and Nyquist's methods for obtaining a stability criterion are explained and the stabilization of an amplifier circuit is discussed.

As already mentioned the fourth chapter deals with the counter-coupled amplifier. The errors caused by non-linear distortion, by noise voltage and by fluctuations of the amplification, the general connexion and mode of action of counter-coupling, the reduction of faults, passive networks, main amplification and special cases are discussed and some practical hints are given for the range of application of counter-coupled amplifiers and their design.

Of particular value also for mechanical engineers concerned with regulating systems is the fifth chapter which deals with mechanic, electric and mechanic-electric transmission systems. The analogies between mechanical and electrical switching elements are shown and the differential equations for simple connexions are derived both for electrical and mechanical systems.

The book is written in a very fluent and readable style. A welcome feature is that at the end of each chapter a concise summary of its contents is given in a few brief sentences. Throughout the book numerous examples show the application of the theories to selected problems. The book is well produced though it must be mentioned that some minor errors and misprints besides those listed in a fly leaf supplied with the book could be noticed. The careful reader will find no difficulty in tracing and correcting them. A list of symbols used, of references to literature and an adequate subject index are provided. Author and publishers may be congratulated upon this valuable addition to the literature of a specialized but important field of engineering.

R. NEUMANN.

Modern Electroplating

Edited by Allen G. Gray. 561 pp., 40 figs. Medium 8vo. John Wiley & Sons, Inc., New York. Chapman & Hall, London. 1953. Price 68s.

THE purpose of the book is to present the details of today's commercially available processes, not only to the electroplating industry, but to those industries which may be considering or using the processes. It is written by thirty-nine experts, each currently active in his field and each chapter contains references and an adequate bibliography.

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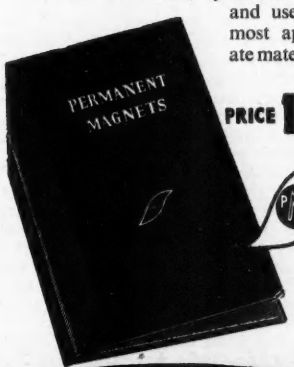

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The Insulation of Electrical Equipment

Edited by Willis Jackson. 340 pp., 80 figs. Demy 8vo. Chapman & Hall Ltd. 1954. Price 42s.

THIS book comprises a series of lectures delivered at a post-graduate vacation school at the Imperial College of Science and Technology in London in 1952. Both theory and practice are covered, or it may be expressed as the physics and the engineering aspects, including such subjects as the general properties related to structure of the material, permittivity, dielectric loss and breakdown, followed by the practical aspects commencing with a classification of insulating materials and chapters dealing with specific fields of use, such as communications, cables, machines, transformers and switchgear. The final chapter (No. XI) deals with insulation testing. Authors include manufacturers and non-manufacturers, and the whole is edited by an acknowledged authority on recent theoretical studies in insulating materials. Although the electronic engineer may not be interested in the applied "power" chapters, other than that on communications components, all the fundamental physics will be of value, as to all electrical engineers. There are most useful chapter bibliographies which include the relevant Standards, Reports and Specifications of the B.S.I., E.R.A. and R.C.S.C. as well as comprehensive references to books and papers. Such a book cannot fail to be a standard work on the subject of insulation and its application. The production of the book is excellent and includes plates on art paper; almost a novelty in these days of post-war economies.

E. H. W. BANNER.

The Physics of Experimental Method

By H. J. J. Braddick. 404 pp., 85 figs. Demy 8vo. Chapman & Hall Ltd. 1954. Price 32s.

PRIMARILY intended for advanced students, this book gives practical data and theory relating to experimental physics. Vacuum, optical, photographic, nuclear physics and electronic circuit techniques are described in sufficient detail for their application in experiments to be understood. A chapter is devoted to magnetic and electrical measurements, mainly the measurement of small voltages and currents, and another deals with the natural limits of such measurements. These bring out many points not always appreciated by physicists. A very useful chapter deals with computation and the evaluation of errors in experimental results. Aspects of the mechanical design of apparatus are reviewed, and much useful data is provided on the physical properties of traditional and new materials of construction and their working.

This very wide field is covered in 400 pages but, not only has Dr. Braddick provided sufficient detail for students, he has produced a very useful reference book. The material is up to date and lucidly presented with points illustrated by well-chosen examples.

It is perhaps unfortunate that some unusual symbols occur: for example, ν is used for frequency and Y for Young's modulus. Though the book recommends B.S.S. 530 for guidance on drawing circuits, unconventional and inconsistent circuit symbols are used, and the circuits are not always clear. Some component values are given but are of little use since valve types and the remainder of the components are unspecified. The isolation of apparatus from uncontrolled outside disturbances, such as vibration, is discussed but there is little mention of temperature or voltage stabilization. The latter is represented only by a few circuit diagrams which have strayed to the nuclear physics chapter. These could well have been included in the section on feedback or, at least, a reference made to the text books on the subject. Cloud chambers are discussed at greater length than is likely to be required by the average physicist. On the other hand, the section describing kinetic vacuum technique is very brief. The usefulness of the book to post-graduate readers would be increased if there were more references, particularly to text books, as these are often more useful than specific papers.

There are very few misprints in the book, and the production is of a high standard with a good index. Though not attempting to be comprehensive, it will nevertheless be of great value to degree or research students, and to part-time Higher National Certificate students working in physics laboratories. It can also be recommended as a work of reference to the practising physicist or the electronic engineer working with physicists.

M. W. JERVIS.

Magnetic Amplifiers and Saturable Reactors

Edited by M. G. Say. 199 pp., 50 figs. Demy 8vo. George Newnes Ltd. 1954. Price 21s.

PROFESSOR SAY has edited a timely volume, of value to practical engineers, and a source of stimulation to designers in its simplification of the subject of many highly analytical scientific papers.

It is a measure of the calibre of the contributors that they write from experience in such companies as B.T.H., Metropolitan-Vickers, Electro-Methods and Elliott Brothers. It says something for the editor's organizing ability that the several sections are complementary and of fairly even quality. This form of multiple authorship is often used in the U.S.A., notably in the M.I.T. Radiation Laboratory series, and it has the merit that a textbook can appear more quickly and be of wider scope than a review by a single author.

In this case the latest reference given is August 1953, and the book was issued early in 1954: the publisher also issues magazines and no doubt could provide editorial facilities to speed up the process further still. It is of interest that they promise a volume on transistors, and these two volumes together will underline the "new look" in electronics which we may not yet fully recognize. For example the authors mention a servo amplifier in which a magnetic amplifier output stage took only 25mA as compared with the 120mA of the valves it replaced. Similarly we know of hearing aids where the substitution of a single transistor has multiplied the battery life four times! These are engineering advances of the same order as the change from cast iron to steel, and from steam to jet engines. There will be few readers of the present volume who will not be introduced to at least some new applications of magnetics.

Mr. W. S. Melville contributes a clear introduction to magnetic principles, and treats the mechanism of saturable reactors and magnetic amplifier circuits in an easily followed step by step description, with simplified analyses that will appeal to the practical designer.

In a chapter on construction Mr. J. A. Lunt sets out mechanical details which probably have not appeared in a coherent form elsewhere. Mr. Baracz outlines the basic push-pull forms of magnetic amplifiers, and Dr. Frost Smith and Mr. P. D. Atkinson deal ably with the important magnetic modulators, of which this must be the first comprehensive review. They then go on to describe many applications in power control, and in instrumentation.

The comparison of performance of sensitive amplifiers must depend on a definition of the term "zero stability," and in attempting this on page 126 as "the input power required to produce a change of output equal to that produced by zero-drift" the authors omit the parameters of time and bandwidth or information content, a not uncommon error. Surely Williams and Noble's second harmonic amplifier with a stability of 10^{-13} watt and a bandwith of 3 cycles deserves a better figure of merit than the contact modulated amplifier of Liston for which 10^{-10}watt is quoted, although the time constant is many seconds? In no case, except figure 4-8, is the time interval of the drift measurement indicated.

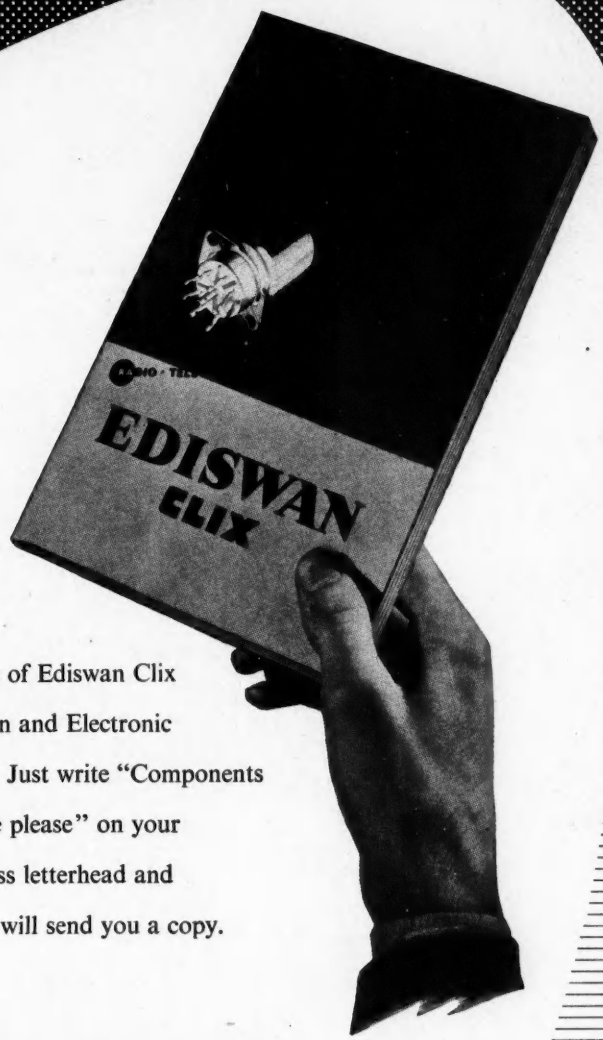
For future editions an attempt at some such "figure of merit" is suggested, together with a discussion of the interchangeability of its parameters such as drift versus time constant. One reference is made on page 2 to amplifiers responding in one cycle of the supply, but this important aspect is not pursued, nor is there any attempt to explain why an amplifier excited at 25kc/s can realize a signal frequency response of only up to 3kc/s. The section on binary digital circuits contains some useful data, but it is less comprehensive than the surveys made of the other applications.

DENIS L. JOHNSTON.

The Mechanism of Economic Systems

By Arnold Tustin. 161 pp., 55 figs. Demy 8vo. William Heinemann. 1953. Price 25s.

THE author is Professor of Electrical Engineering in the University of Birmingham and the book explains recent advances in our understanding of the mechanism of booms and slumps and economic fluctuations generally. This account will interest not only economists and students of economics, but it also provides for engineers and technicians an approach to the possibilities of modern economic developments in terms with which they are already familiar.



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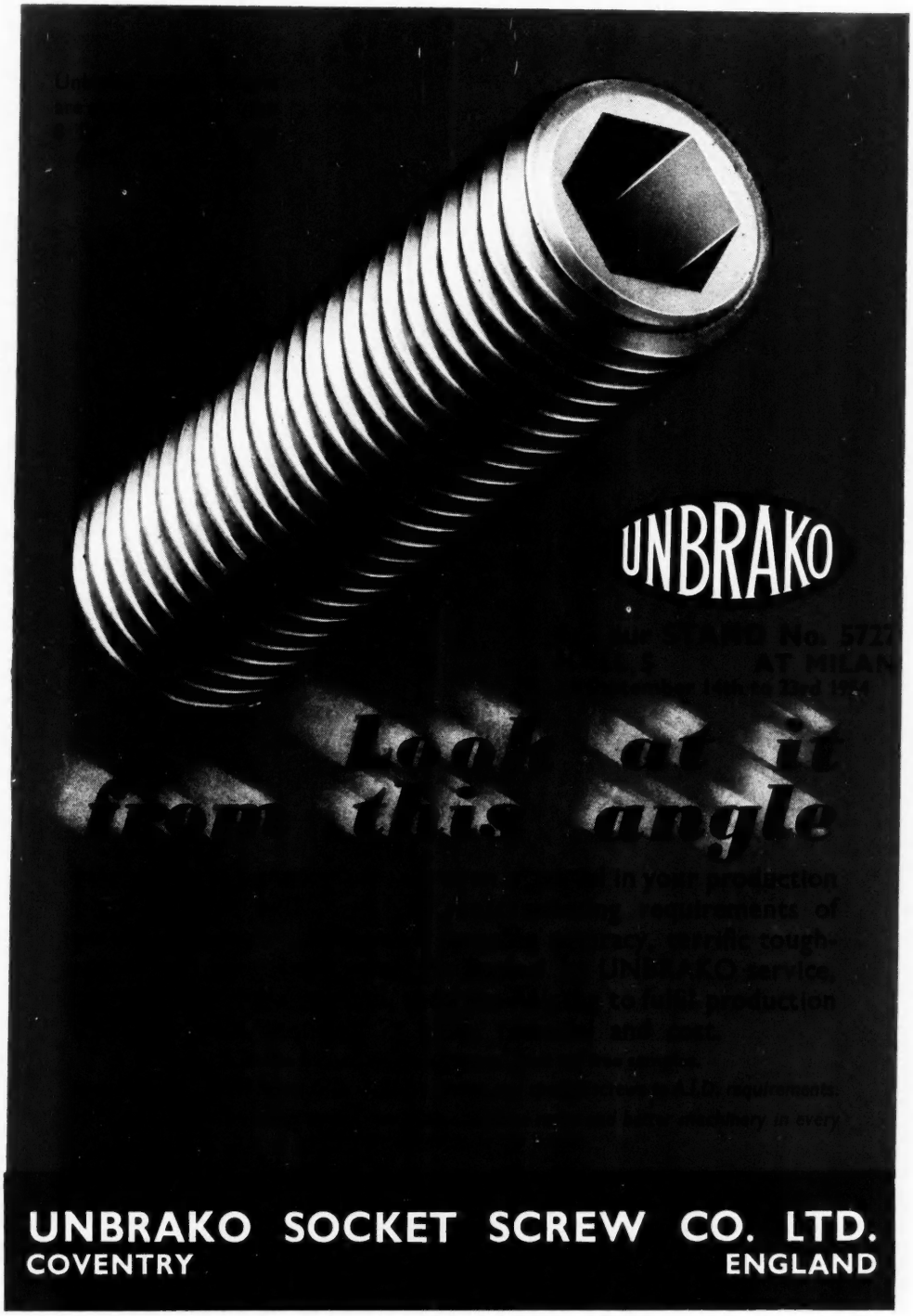
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FZ11 & 12	1 or 2	B	3.0	4.0	1/100
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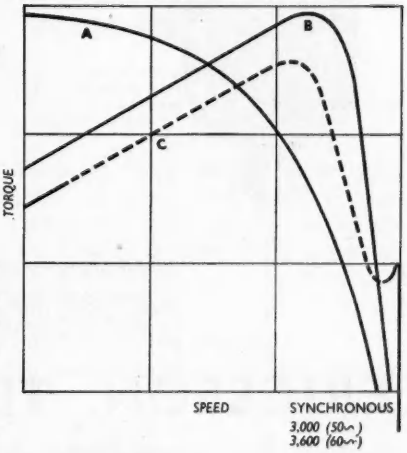

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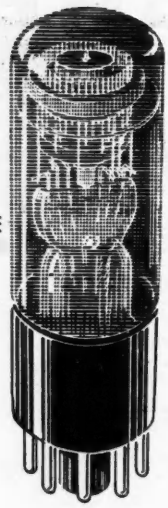

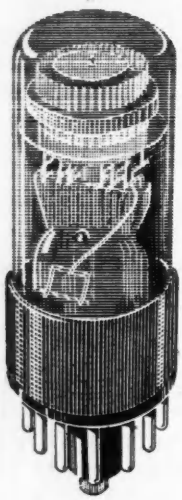

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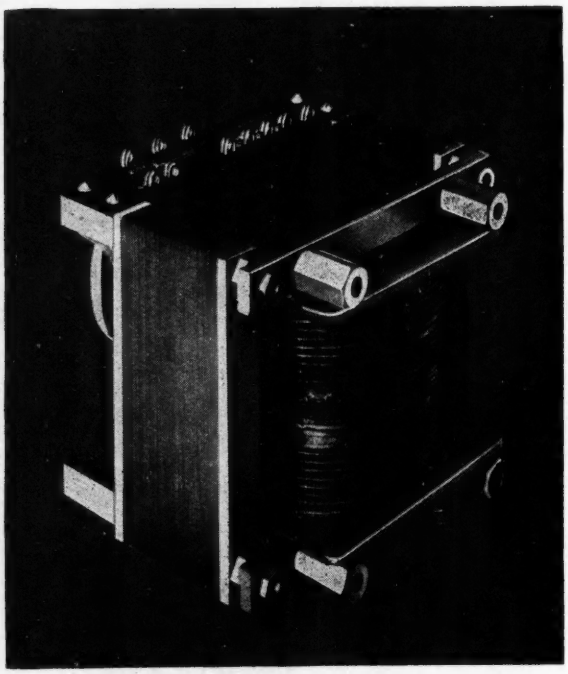
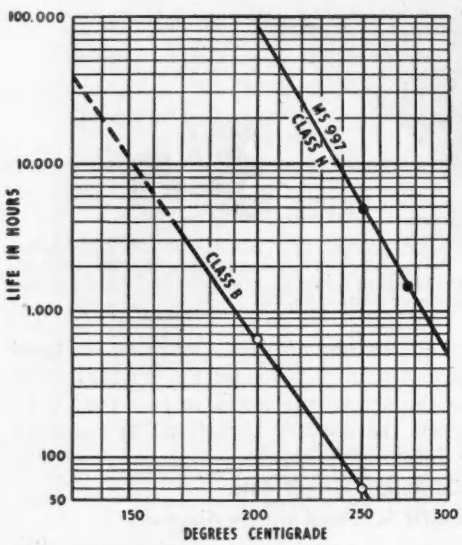
Silicone-bonded insulation includes resin-bonded glasscloth laminates in rod, tube and sheet form that can be machined and fabricated; varnished glasscloth from 0.004in. thick; micanite and mica/glasscloth; varnished glasscloth and silicone rubber sleevings and silicone-enamelled winding wire. Coils are impregnated with silicone varnish MS997. Silicone insulation will withstand operating temperatures at least 50°C. higher than conventional insulation. Where extreme compactness of design is necessary, particularly if excessive temperature rises are likely, silicone insulation is recommended.



A recent, typical example of a component designed for silicone insulation is the power transformer made by Marconi's Wireless Telegraph Co. Ltd. for use in B.B.C. television cameras. These transformers are insulated with silicone-bonded materials and impregnated with silicone varnish for operation up to 150°C. By using silicone insulation the transformers give more power per pound weight than with any other form of insulation.



THIS GRAPH compares the thermal endurance of silicone varnishes. The "life" is based on the hours necessary to reduce the electric strength of varnished glasscloth to half its initial value. Measurements were made on strips of heat-cleaned 0.004 in. glasscloth. Each strip was dip-coated with the varnish, cured and then dipped and cured again to give a finished thickness of 0.007 ± 0.001 in.

BRITISH MADE SILICONES

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MIDLAND SILICONES LTD

(An associate company of ALBRIGHT & WILSON LTD.)

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TRW/MS36

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Marconi's fitted the first ship with wireless and by 1907 200 ships and more than 100 shore stations had been equipped. Today practically every vessel that ventures on the high seas carries wireless. All radio approach and marker beacons around the British Isles have been designed and manufactured by Marconi. The mariner is warned of hazards and guided into safe channels by Marconi equipment in nearly every principal shipping lane of the world.

MARINE BEACONS AND NAVIGATIONAL AIDS

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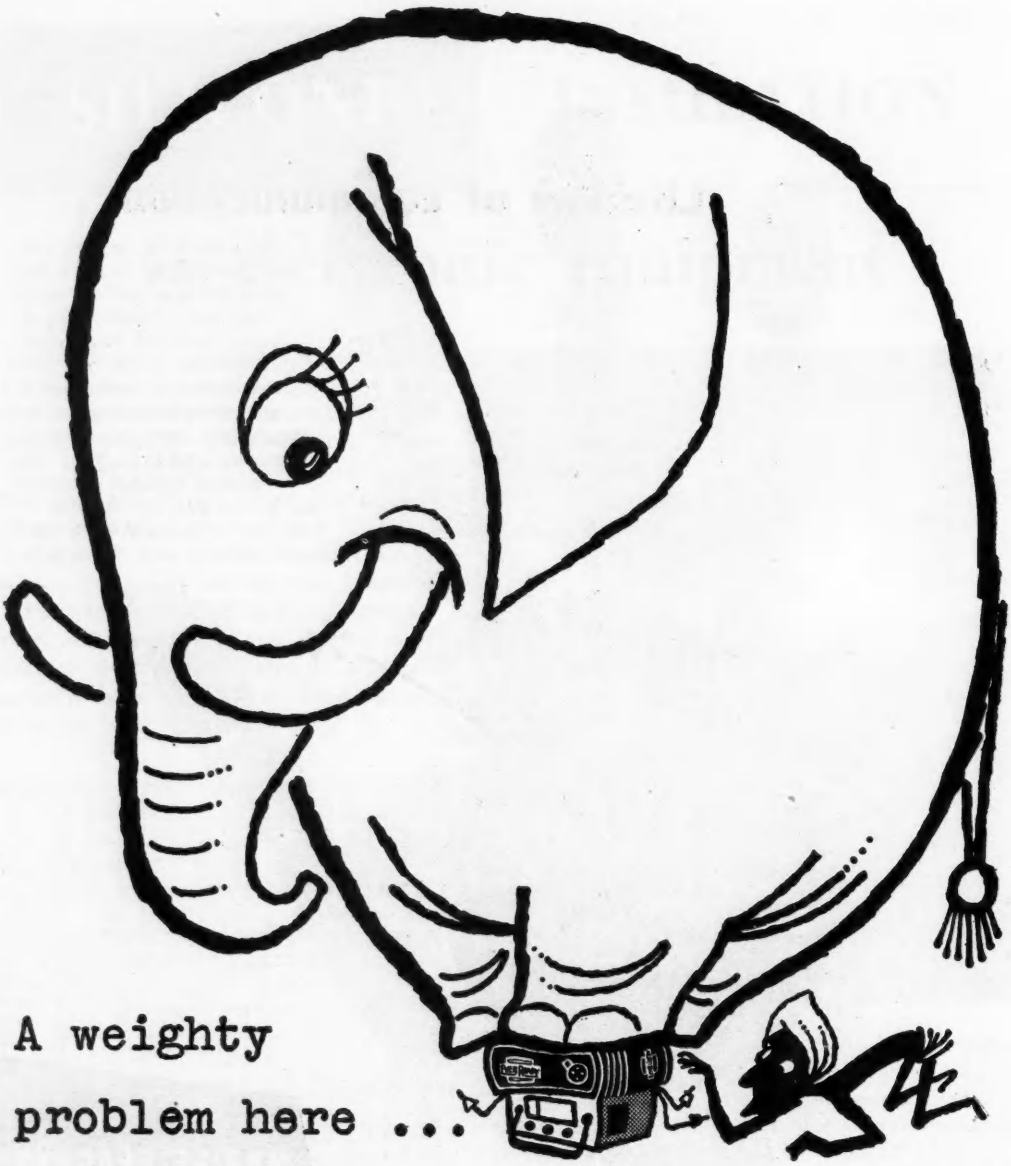
LG 2



A weighty problem here ...

The portable had everything—except sufficient room to take the battery. Brute force was no solution. Only specially designed batteries could save the set.
Designers of battery radio sets should note this dilemma. Time, effort (and money) are wasted if you prepare a design and then find you haven't left room for the battery. Naturally, Ever Ready can make up special units but it's so much simpler to call us in early so that your set is designed, if possible, to take one of our many standard batteries.

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DRY BATTERIES FOR RADIOS

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The DALIC PROCESS of Electrodeposition provides a wide range of coatings on to most basis materials, including aluminium. It is particularly suitable for plating selected areas without stopping-off, for on-site work, and for plating assemblies or components which may not be immersed in plating solutions.

For such non-decorative purposes as building-up worn or overmachined parts, the extremely high speed of deposition and the accuracy with which deposit thickness can be controlled are most attractive features. Deposits are characterised by low stress, extremely fine grain, perfect adhesion and complete absence of porosity.

The DALIC PROCESS has received overwhelming acceptance by industry and recent installations have been made in the electronics, motor car, radio and television and armaments industries, in the Ministry of Supply, and in various research establishments.

Characteristics of Dalic Deposits

Deposit	Maximum Current density (amp./sq. ft.)	Brinell hardness of deposits	Time to deposit 0.0001 in.* (sec.)
Bismuth	1,250	50	7.6
Cadmium	6,000	40	2.5
Chromium	4,000	600	63
Cobalt	1,500	250	7.6
Copper	6,000	150	2.5
Gold	2,000	100	6.2
Indium	4,000	<1	2.5
Iron	3,000	175	10.2
Lead	5,000	20	3.8
Nickel	5,000	500	5.1
Platinum	3,000	200	17.5
Rhodium	3,000	500	70
Silver	1,250	60	5.1
Tin	5,000	1	2.5
Zinc	3,000	70	3.8

** Assuming the pad electrode employed were stationary. Since, in practice, it is moved over the surface being plated, this time should be increased by the area of the surface divided by the area of the pad.*

A practical demonstration at our laboratories will be given without obligation

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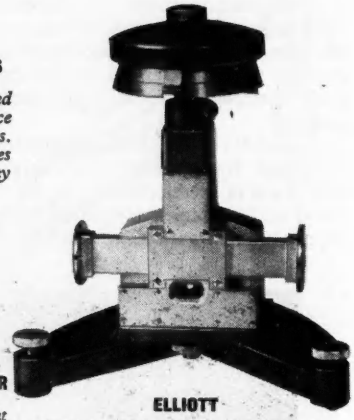

ELLIOTT
3·2 cm. TORQUE VANE WATTMETER

For the absolute measurement of microwave power.

In addition to the range of instruments for manual measurement of microwave parameters — available singly or in complete Test Benches — ELLIOTT produce automatic instruments which measure accurately, at highest speed, the unknown characteristics of components and aerials. The ELLIOTT Swept Frequency Impedance Meter and the ELLIOTT Aerial Amplitude and Phase Plotter are two of the ELLIOTT instruments which have gained wide acceptance in this field. Full details on request.

ELLIOTT BROTHERS (LONDON) LTD., CENTURY WORKS, LONDON, S.E.13 (TIDEWAY 3232)

Marconi R.F. Test Set Type TF 890A

A Combined Signal Generator, Frequency Meter, Power Meter and Spectrum Analyser for Microwave Measurements

This new Marconi Test Set is for use in the frequency range 9000 to 9680 Mc/s. Output from the *signal generator* section can be c.w., or either pulse or sawtooth frequency modulated, and its level can be varied from +6 to −115 dB relative to 1 mW. The measurement range of the *power meter* is from +47 to −10 dB relative to 1 mW. The sensitivity of the *spectrum analyser* section is sufficient to allow its use with transmitter mean powers as low as 1 watt. The *waveguide coupling components* supplied with the Test Set include a switched two-way directional coupler for measuring v.s.w.r.

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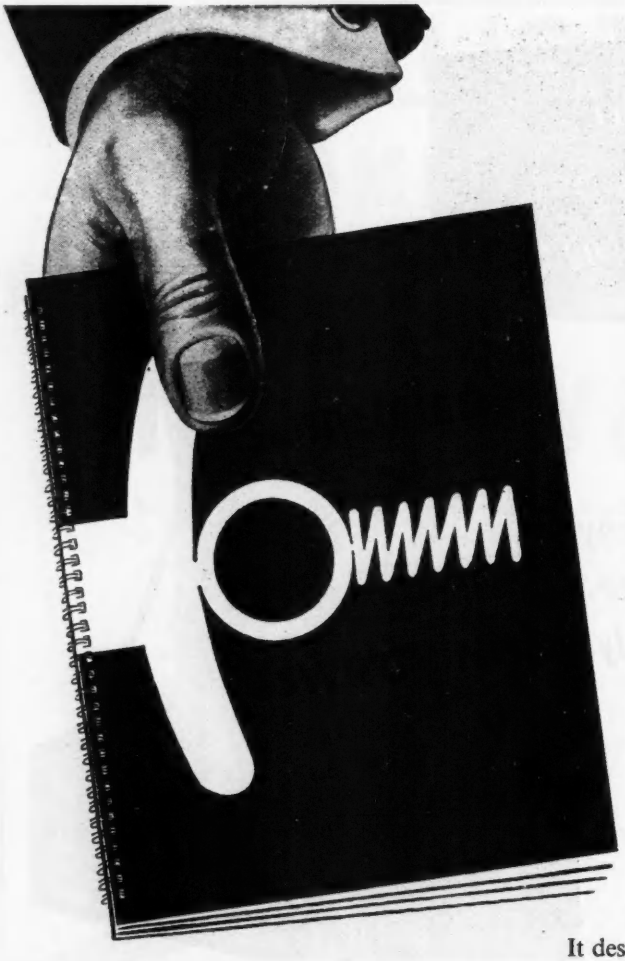
TC 53



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It describes robustly made switches — for duties ranging from light domestic to heavy industrial applications — they provide a new and simpler approach to switching problems : they save space, wiring, money . . . How and why you can see for yourself in "Simplified Switching".

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Austinlite rotaries differ from other rotary switches in this : every switch is built for its job ; and Austinlite engineers take as much trouble to see that you get the right switch for the job—whether you want one, a hundred, or a thousand.

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The 12AT7 is a very reliable frequency changer and is widely used in modern TV receivers, VHF and UHF communications equipment. It is also frequently employed in industrial equipment, computors, navigational aids and test equipment.

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Use the BRIMAR
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with improved performance
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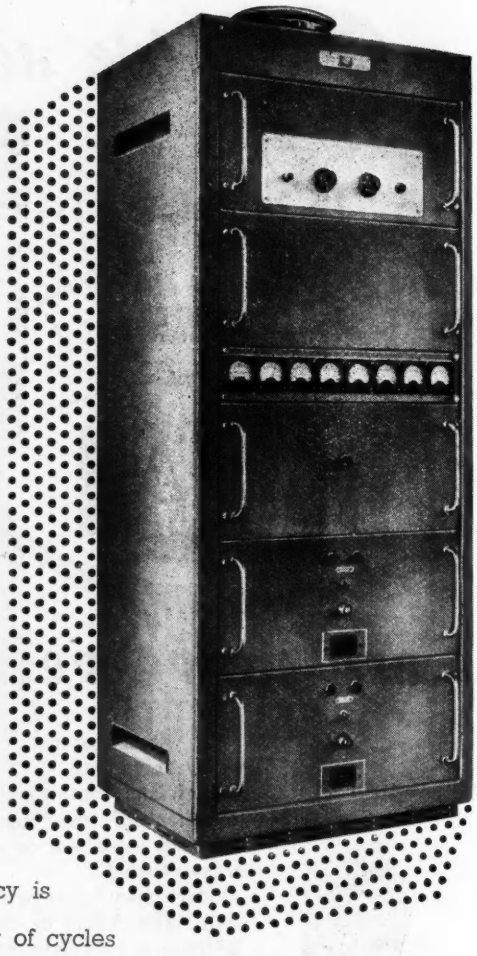
AUTOMATIC FREQUENCY MONITOR (20 Mc/s)



Designed for the measurement of any frequency in the range 10 c/s to 20 Mc/s with a basic accuracy of ± 1 part in 10^6 ± 0.1, 1.0, or 10 c/s. Higher accuracies available if required. The unknown frequency is determined by counting the number of cycles that pass through a 'gate' open for a selectable time interval of 0.1, 1.0, or 10 seconds. The result is presented on eight panel mounted meters each scaled 0 to 9 and is in decimal notation. Full information available on request.

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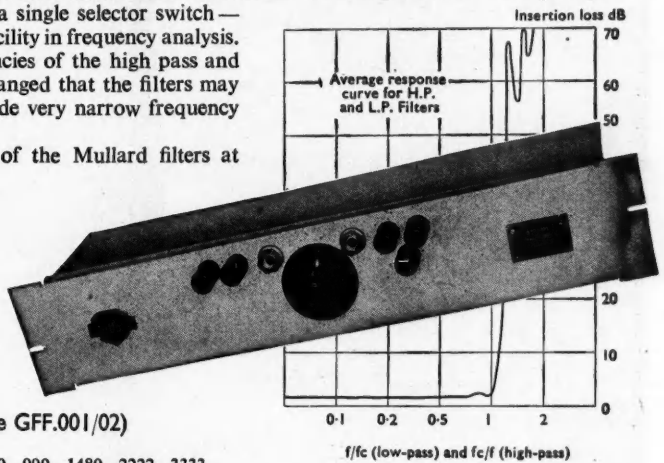
TEN CUT-OFF FREQUENCIES IN ONE COMPACT PANEL

THESE Mullard variable cut-off filters, originally developed in conjunction with the British Post Office, represent a marked advance in filter technique. New design features together with the use of Ferroxcube pot cores have resulted in a valuable reduction in panel size, as well as high attenuation characteristics outside the passbands. Frequency ranges are controlled by a single selector switch — an especially important facility in frequency analysis.

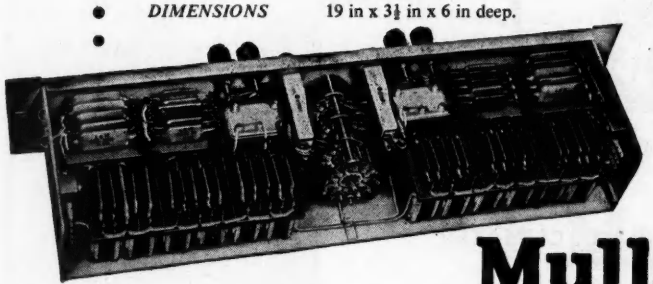
The ten cut-off frequencies of the high pass and low pass filters are so arranged that the filters may be used in pairs to provide very narrow frequency samples.

Brief technical details of the Mullard filters at present available are given here; communication engineers and research workers who may require more comprehensive information are invited to apply to the address below.



High-Pass Filters (Type GFF.001/02)

CUT-OFF FREQUENCIES (fc)	440, 660, 990, 1480, 2222, 3333, 5000, 7500, 11250, 16800 c/s selected by 10-way switch
IMPEDANCES	Input and output 600 ohms, balanced or unbalanced
STOPBAND ATTENUATION	At 0.8 x fc — 50 dB At 0.6 x fc — 60 dB
PASSBAND ATTENUATION	3dB ± 1 dB from 1.1 x fc to 20 or 25 kc/s depending on cut-off frequency (fc)
DIMENSIONS	19 in x 3½ in x 6 in deep.



Low-Pass Filters (Type GFF.001/01

CUT-OFF FREQUENCIES (fc)	400, 600, 900, 1350, 2025, 3040, 4500, 6830, 10250, 15400 c/s selected by 10-way switch
IMPEDANCES	Input and output 600 ohms, balanced or unbalanced
STOPBAND ATTENUATION	At 1.25 x fc — 50 dB At 1.35 x fc — 60 dB
PASSBAND ATTENUATION	2dB ± 1dB from 50 c/s to 0.9 x fc
DIMENSIONS	19 in x 3½ in x 6 in deep

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Type 46

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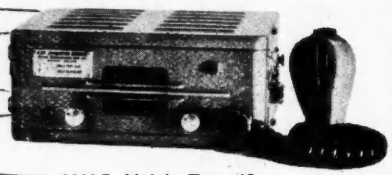

V.H.F. Mobile Type 68

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Mullard Ferroxcube being extruded into rods for H.F. cores.

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The wealth of experience gained from these developments is available to all users of magnetic materials through the Mullard advisory service. An enquiry to the address below will put a team of specialised engineers at your disposal.

Mullard

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'TICONAL' PERMANENT MAGNETS · MAGNADUR (Formerly Ferroxdure) PERMANENT MAGNETS · FERROXCUBE MAGNETIC CORE MATERIAL

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FOR INDUSTRY

High quality material and dimensional precision are attributes of Bullers die-pressed products.
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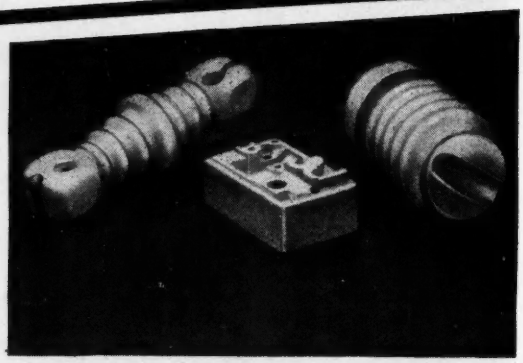

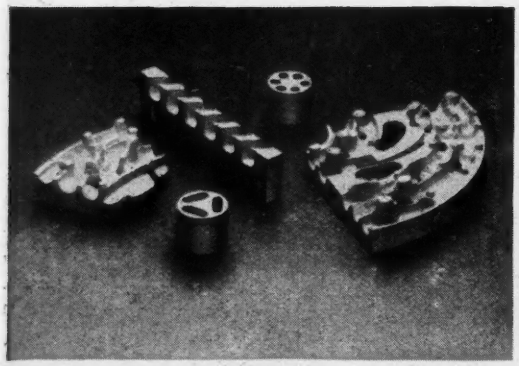

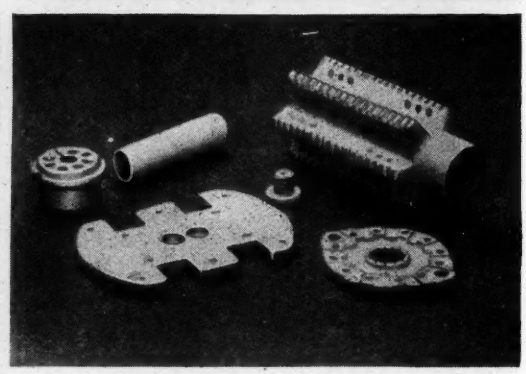

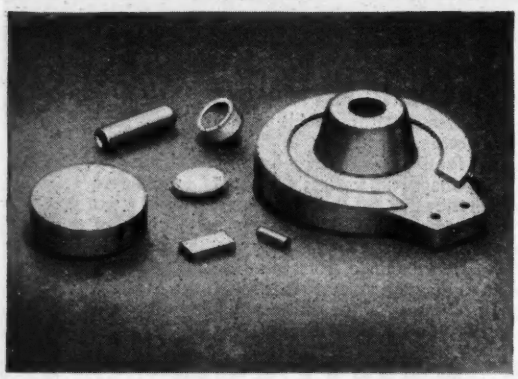

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for general insulation

REFRACTORIES
for high-temperature insulation

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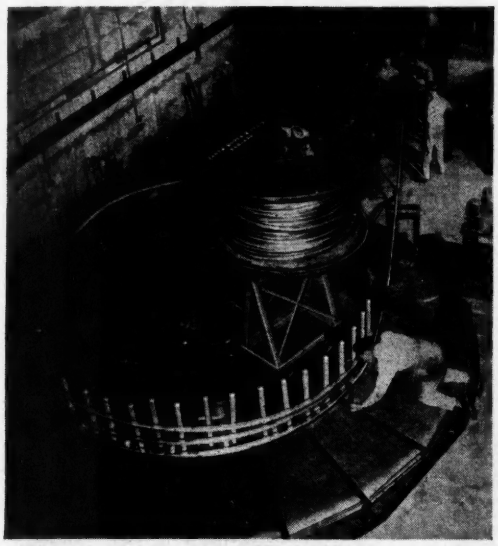
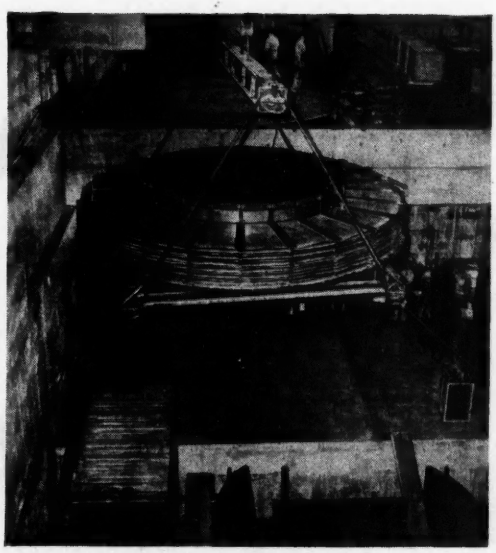
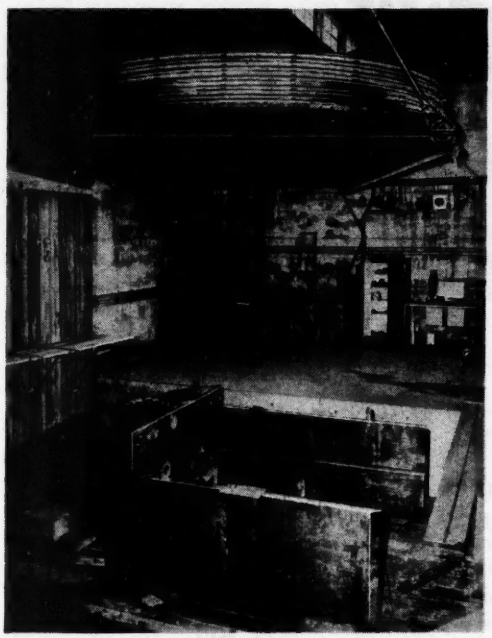


The aluminium being pulled through a tensioning device and wound on to the layer of pancakes that form the magnet energizing coils.



The completed job being lifted from the winding table. The partially built accelerator magnet is shown in the foreground.

CYCLOTRON WINDINGS



Another view of the completed winding.

WITH JAMES BOOTH'S SPECIAL ALUMINIUM SECTION

Following the success at Liverpool University, the Australian National University Research School of Physical Science at Canberra, used a special extruded section of square contour with a central round hole for the windings of the electromagnet of the cyclotron recently constructed in Australia. This meant a demand for 16 continuous lengths of section each 2,300 ft. long, and the successful production of faultless lengths of such extent represents no small metallurgical achievement. If, however, the versatility of aluminium and the flexibility of the extrusion process is used in conjunction with the art and perseverance of our skilled technicians, the most ambitious aspirations of the drawing board can often be brought to reality.

If your problem is unusual—so also will be our endeavours to help you if you care to consult us, without obligation, of course.

Photographs — reproduced by courtesy of the University — show the job in progress.

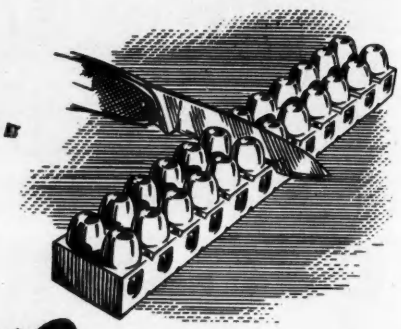
BOOTH
BIRMINGHAM

JAMES BOOTH & COMPANY LIMITED · ARGYLE STREET WORKS · BIRMINGHAM 7

CYC 1

You can bend it..

You can cut it..



—but just try and break THIS terminal block!

THIS component revels in "rough going"; no surfaces are too uneven. Corners and curves that would preclude the use of a rigid type, are just the conditions that show up the novel and useful features of this flexible terminal block. In addition, many of the difficulties experienced when using the rigid type of block are overcome, e.g., broken mouldings due to tightening of screws, lost terminal screws, and the difficulty of modifying to the required number of ways.

In the "Belling-Lee" design the terminal screws are captive, the heads being firmly gripped by the resilient P.V.C. moulding *and cannot be shaken or fall out, even when the block is mounted upside down*, or carelessly mishandled.

The component can be cut with an ordinary pocket knife into smaller groups of terminals as required, and for the purpose of fixing, holes are provided between each pair of terminals.

- ★ **Captive Terminal Screws**
- ★ **Flexible**
- ★ **Easily Sectionalised**
- ★ **Mechanically Shock-proof**
- ★ **Rating 5 amp. Up to 10 amp may be used at designer's discretion**
- ★ **12 Way**
- ★ **Overall size 5″ x .750″ x .625″ high. Holed centres spaced .425″**

Please write for Leaflet P.378/E.E.

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GREAT CAMBRIDGE ROAD, ENFIELD, MIDDX., ENGLAND

7·5 to 250 Mc/s
ON FUNDAMENTALS
IN FIVE RANGES

SINE AND SQUARE WAVE MODULATION

R.F. OUTPUT 1 μV to 100 mV

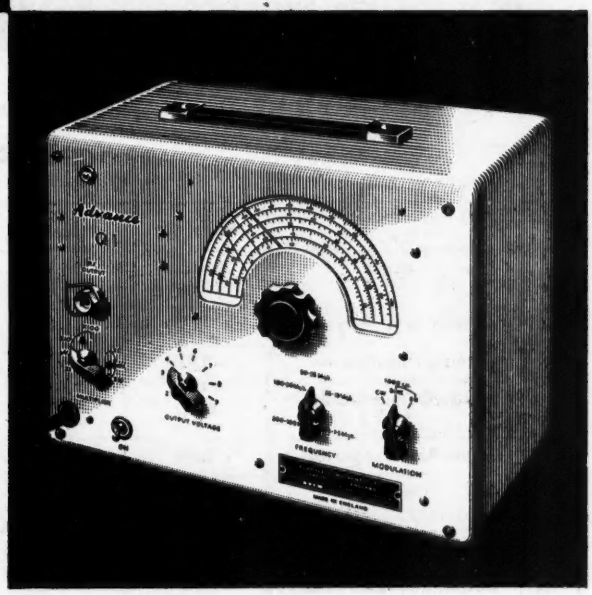
Advance

MODEL Q1

V.H.F. SIGNAL GENERATOR

£45

(LIST PRICE IN U.K.)



Again Advance lead the way—this time with a V.H.F. Signal Generator covering 7.5 to 250 Mc/s, a range that embraces Bands 1 and 2 *and also the impending Very High Frequency Television Transmissions on Band* 3. Moreover, this instrument is available at a price well within the reach of every service man. In the traditional Advance manner, this instrument is designed for simple operation and with a versatility that not only fulfils present needs, but anticipates the even more exacting requirements to deal with the television test problems of tomorrow.

Below are some outstanding features :—

- WIDE RANGE—7.5 to 250 Mc/s
- SINE AND SQUARE WAVE MODULATION
- RELIABLE ATTENUATION
- LOW LEAKAGE—less than 3 microvolts
- TRULY PORTABLE—weighs only 17 lbs.
- COMPETITIVE PRICE

Full technical details available in Folder M/23 on request.

The Q1 provides the ideal complement to the Model E2. These together give complete coverage from 100 kc/s to 250 Mc/s.

ADVANCE COMPONENTS LTD., MARLOWE ROAD, WALTHAMSTOW, LONDON, E.17. *Telephone : LARkswood 4366/7/8.*

GD

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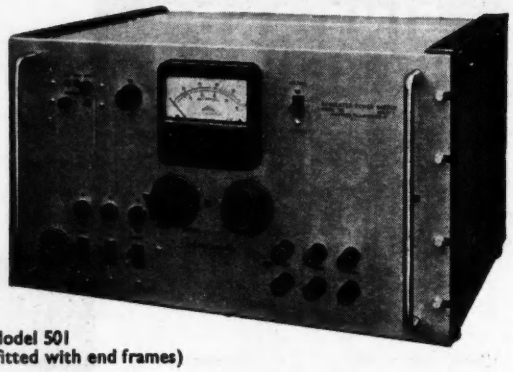
REGULATED POWER SUPPLIES

SERIES 500

An entirely new range of units, designed for the highest possible performance and overall efficiency.

Now in large scale production and available for prompt delivery.



Model 501
(fitted with end frames)

ABRIDGED DATA
(Further information on request)

	Data	Model 501	Model 502	Model 503	Model 504	Model 505
Main +VE Stabilizer	Output	200-500V 250mA	200-500V 250mA	0-500V 250mA	0-500V 250mA	0-500V 150mA
	Number of Ranges	2	2	4	4	1
	Voltage Stabilization	±0.02%	±0.002%	±0.1%	±0.002%	±0.1%
	Effective Output Resistance (max.)	0.2 Ω	0.02 Ω	0.5 Ω	0.02 Ω	0.5 Ω
	Output Ripple (rms. max.)	2mV	1mV	3mV	1mV	3mV
−VE Supply Stabilizer	Outputs	—	—	250V 25mA 0—250V 1mA	250V 25mA 0—250V 1mA	250V 25mA 0—250V 1mA
	Voltage Stabilization	—	—	±0.05%	±0.002%	±0.05%
	Output Resistance (max.)	—	—	1 Ω	0.01 Ω	1 Ω
	Output Ripple (rms. max.)	—	—	2mV	1mV	2mV
Unstabilized +VE H.T. Supply 250mA max.		470V 630V	470V 630V	320V 470V 630V	320V 470V 630V	630V
Unstabilized A.C. Supply		6.3V 10A	6.3V 10A	6.3V 10A	6.3V 10A	6.3V 10A
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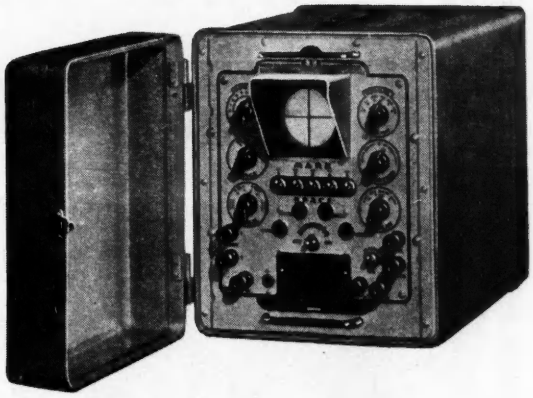
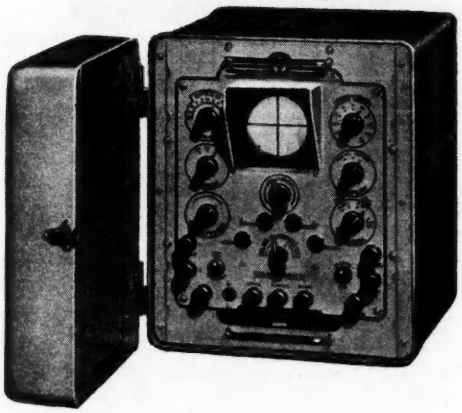
a new T.D.M.S

The T.D.M.S. 5 & 6 are portable sets designed to measure distortion at any point in a radio teleprinter or line telegraph circuit without interfering with normal transmission.
The equipment consists of two units each 12″ x 8″ x 7″ both mains driven and electronically controlled; either may be used independently for certain tests or both may be used in combination to cover a comprehensive range of testing operations.





T.D.M.S. 5

Sends an automatic test message or characters or reversals at any desired speed and/or percentage of distortion. The CRO has a circular time base for distortion measurements or relay adjustment.

T.D.M.S. 6

For distortion measurements on working circuits without interrupting service. Each element of a start-stop signal appears separately on the spiral time base display. Adjustable speeds from 20–160 bauds.

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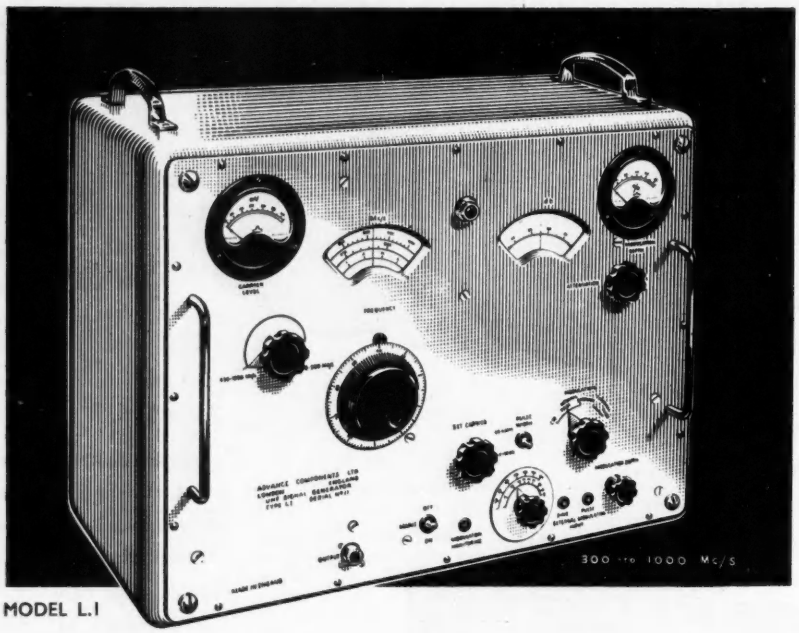

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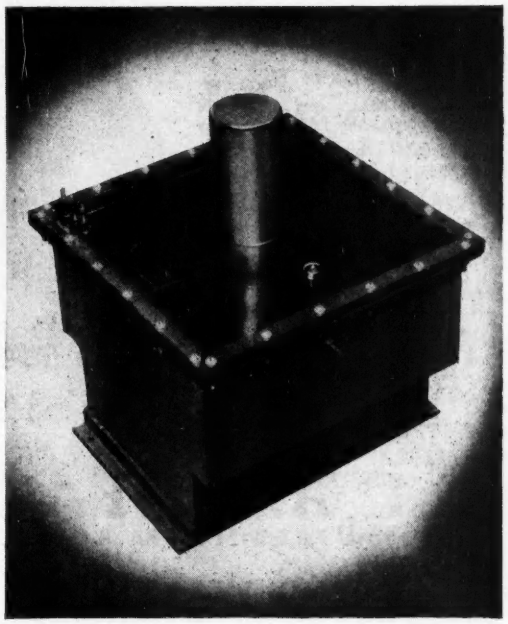
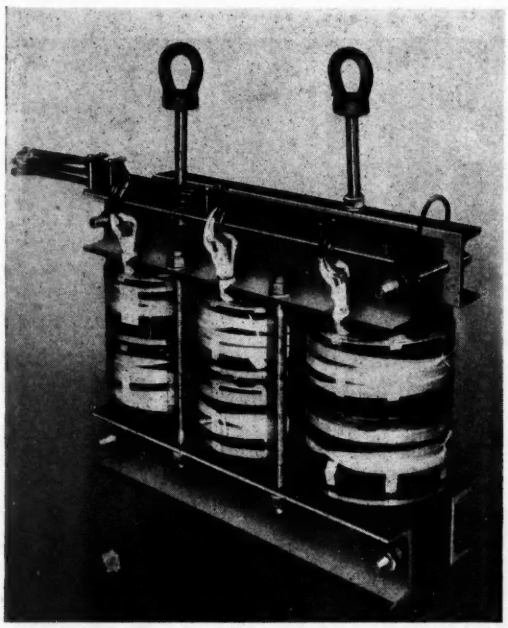


Illustrated on the right is an E.H.T. Transformer, single phase, 50 c/s, voltage ratio 240/75,000, maximum continuous current rating 50 mA. One side of secondary winding earthed. Overall dimensions 17 in. long, 17 in. wide and 18 in. deep, including E.H.T. Terminal.



Illustrated on the left is a 6.25 kVA Transformer, before being assembled into its tank, for supplying a 3 phase rectifier circuit. Voltage ratio 360-390-420/2,250, 50 c/s, Delta/Star, built to B.S. Specification 171.

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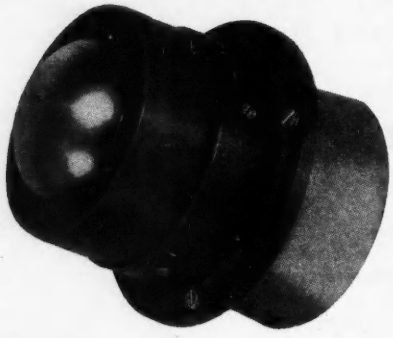

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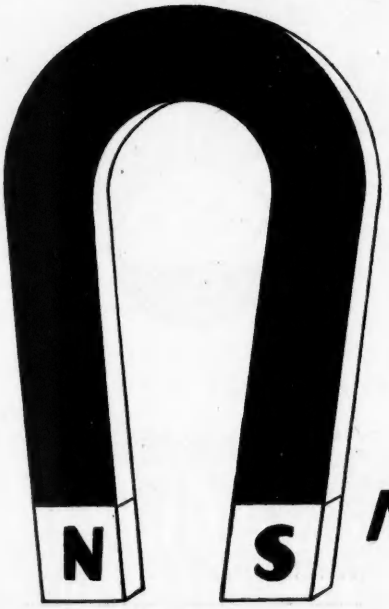

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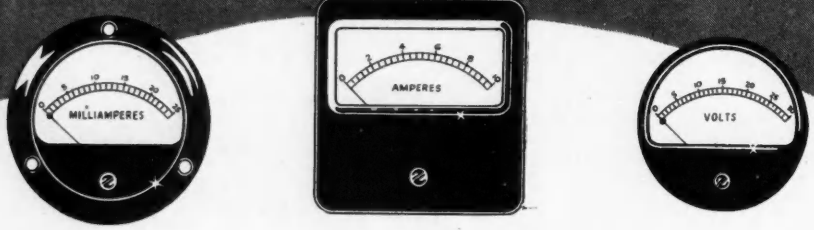

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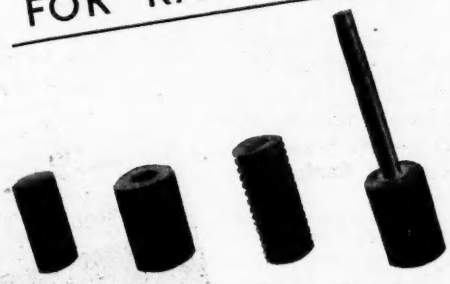

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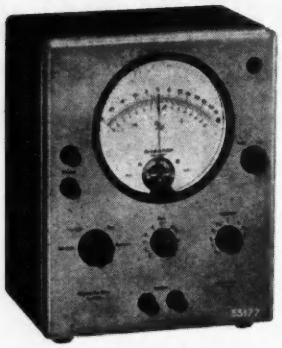

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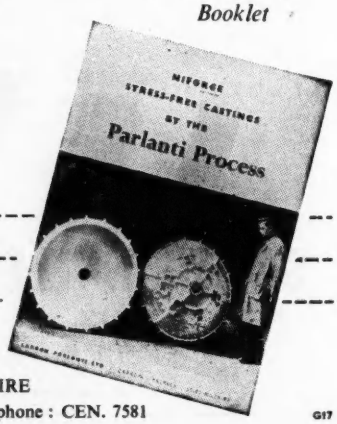

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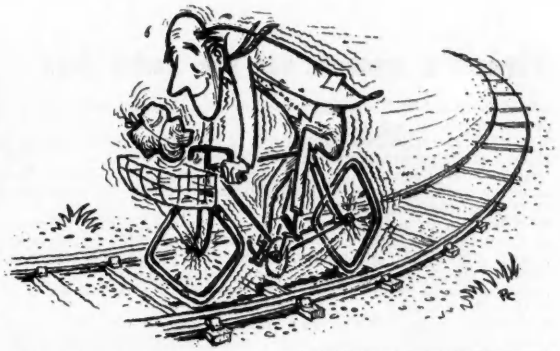

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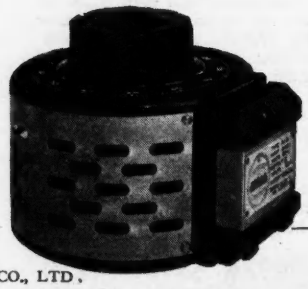

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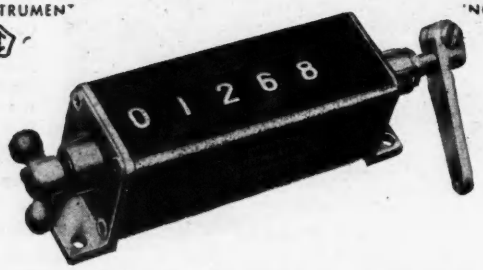

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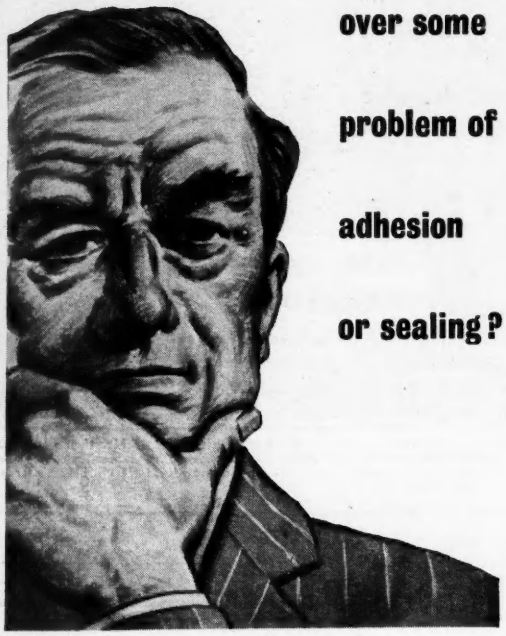

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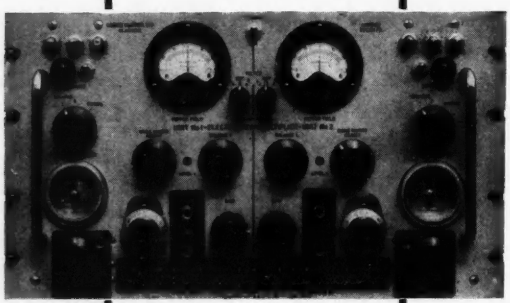

$$y = f_1(x)\left\{f_2(s) + \ldots + f_6(w)\right\} + f_7(z)\left\{f_8(l) + \ldots + f_{12}(p)\right\}$$

or for example :

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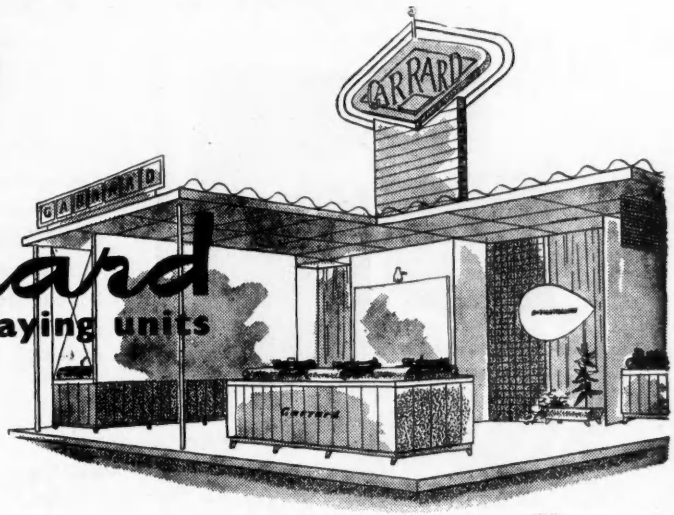

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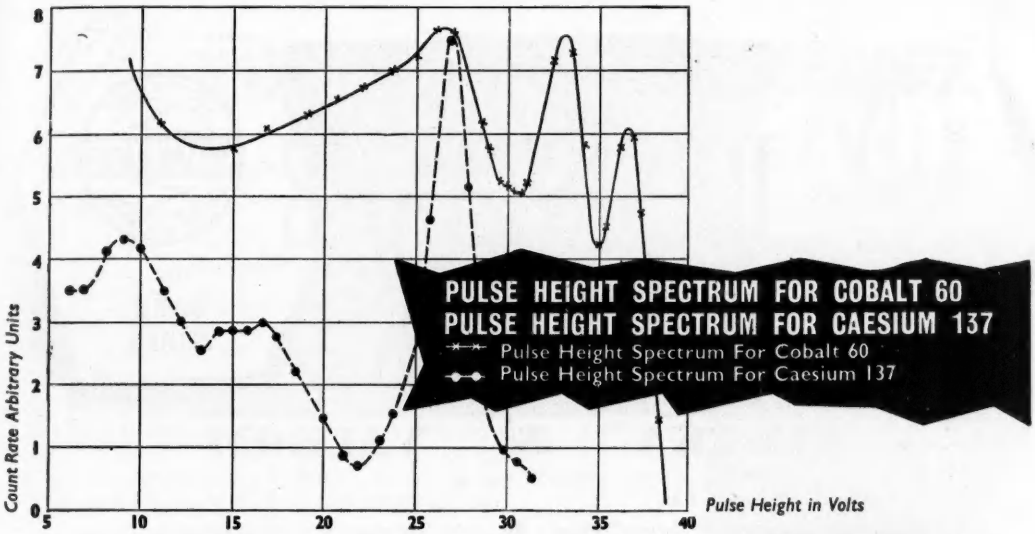
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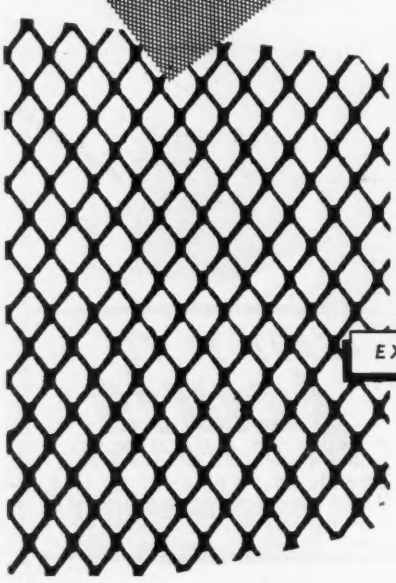

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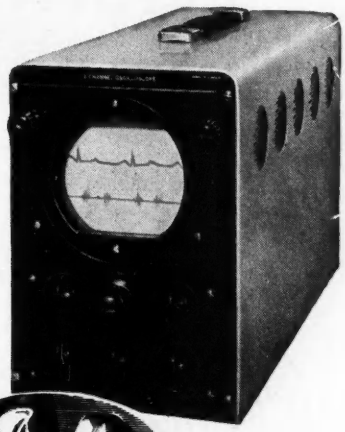

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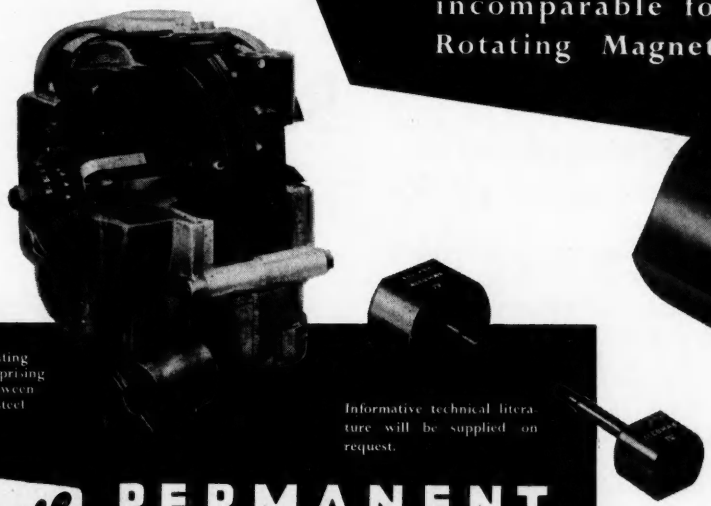

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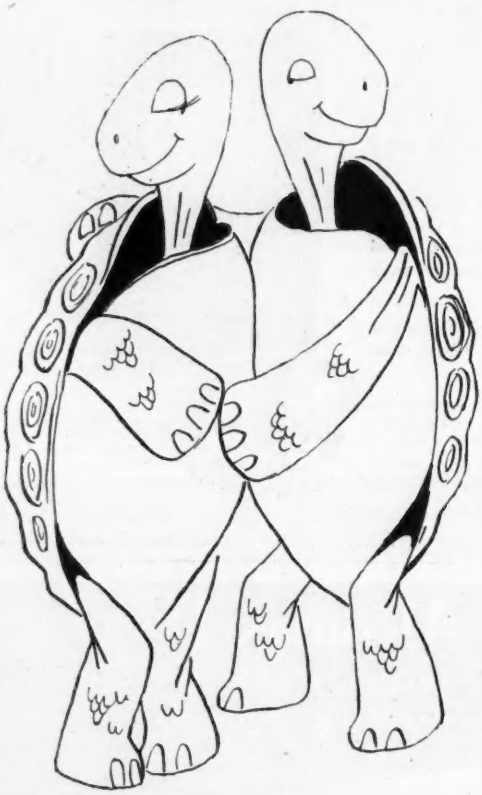

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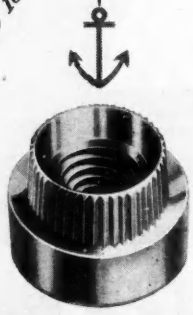

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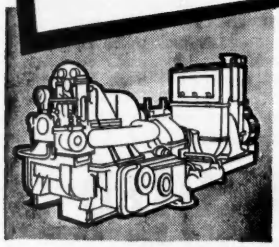

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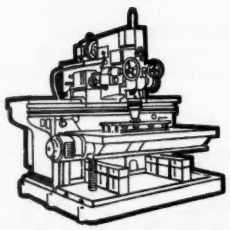

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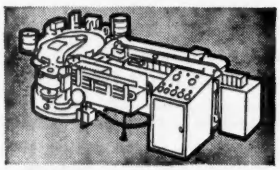

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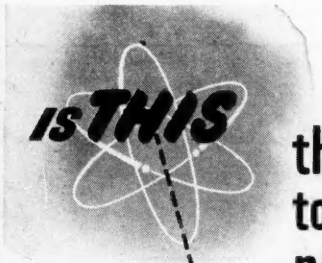

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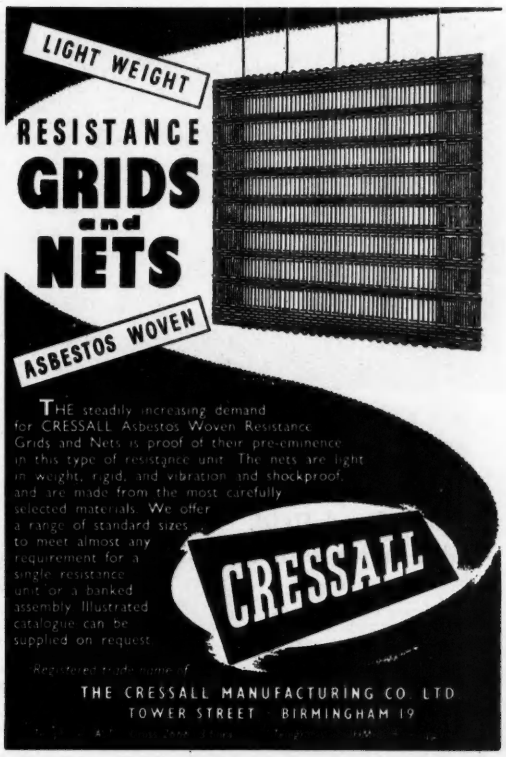
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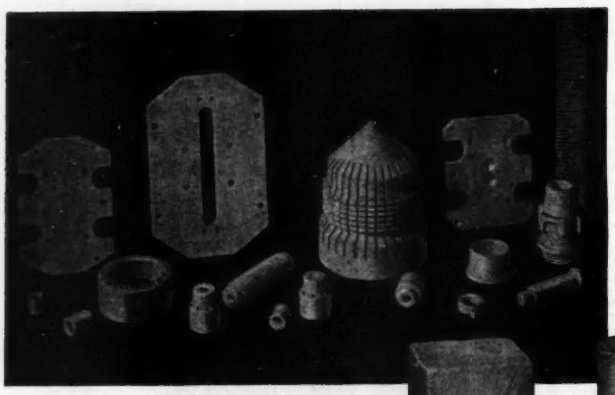

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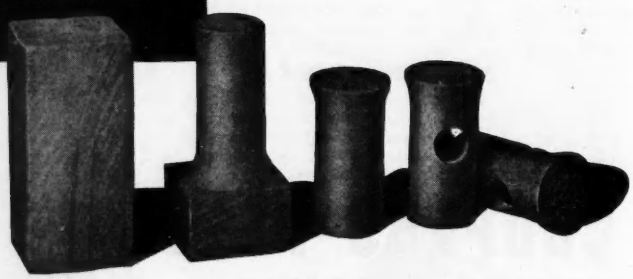

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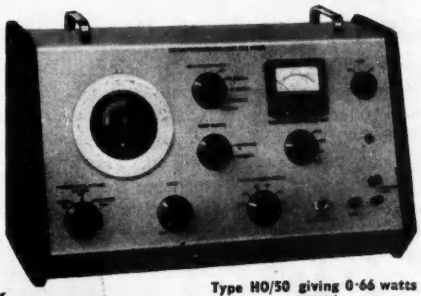

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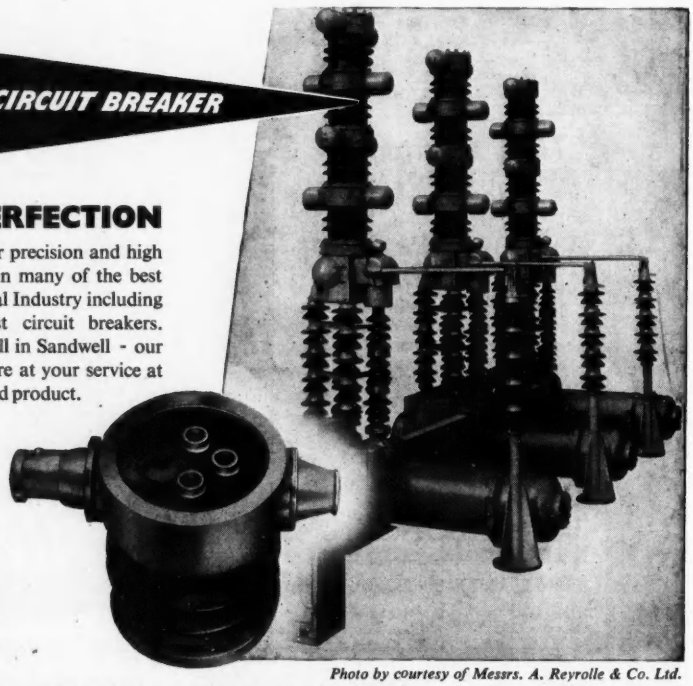

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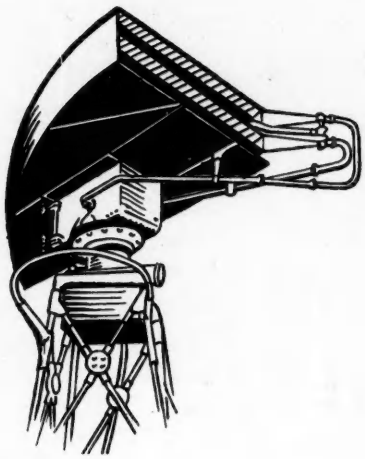

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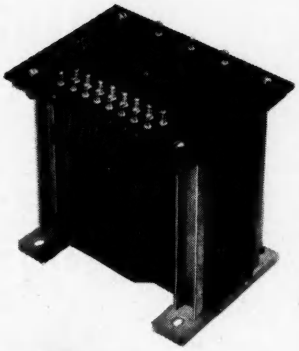

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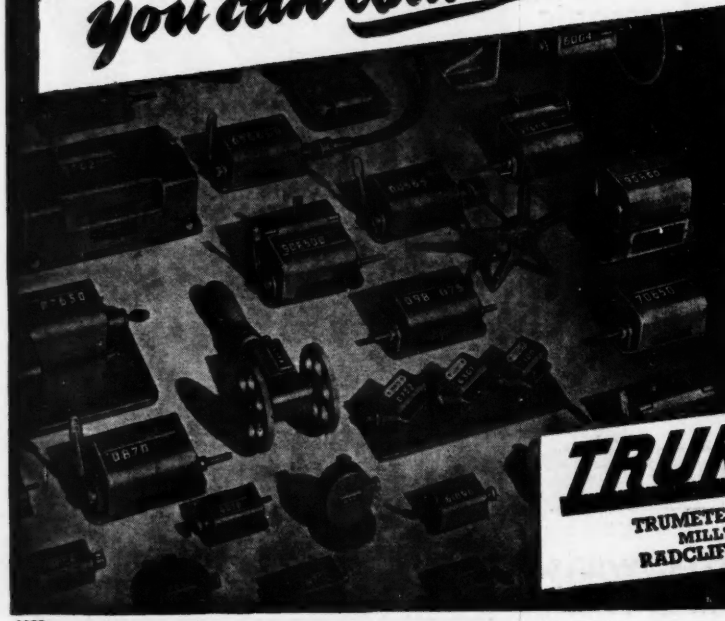

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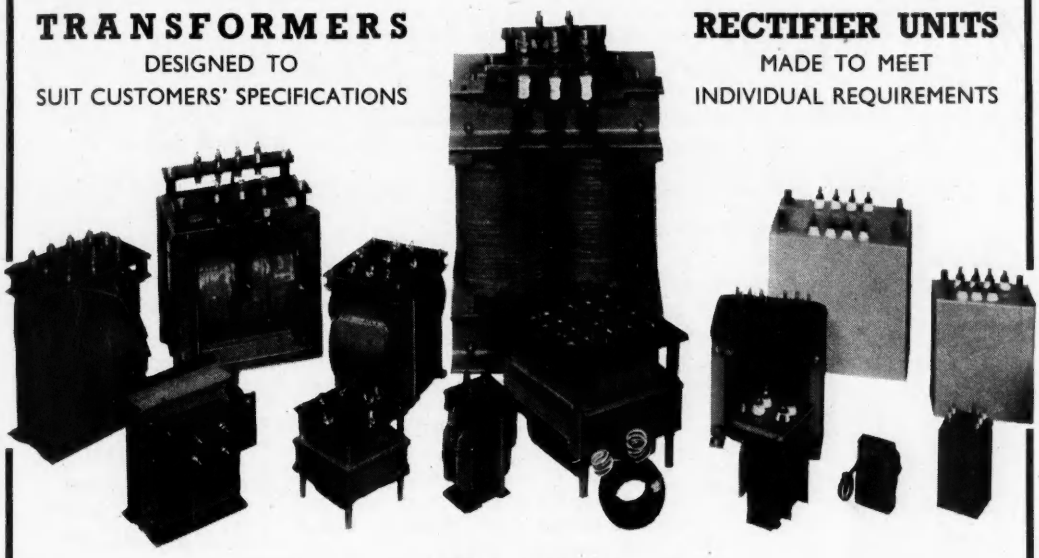

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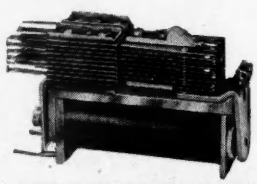

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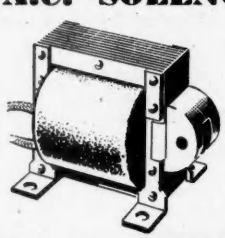

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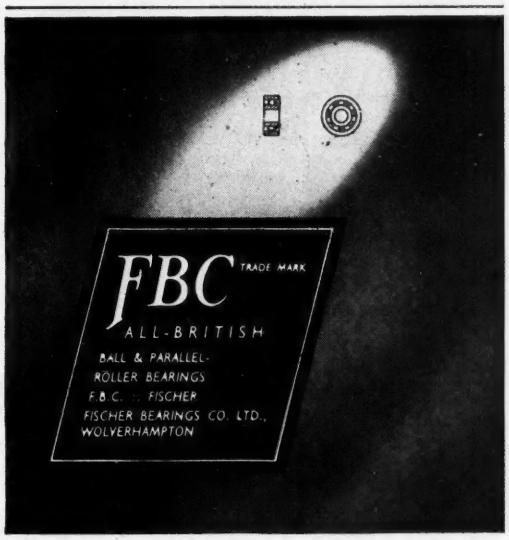

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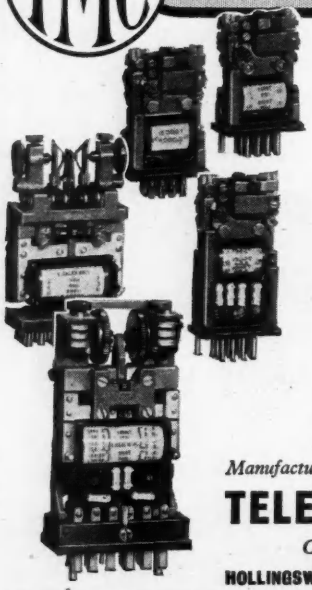

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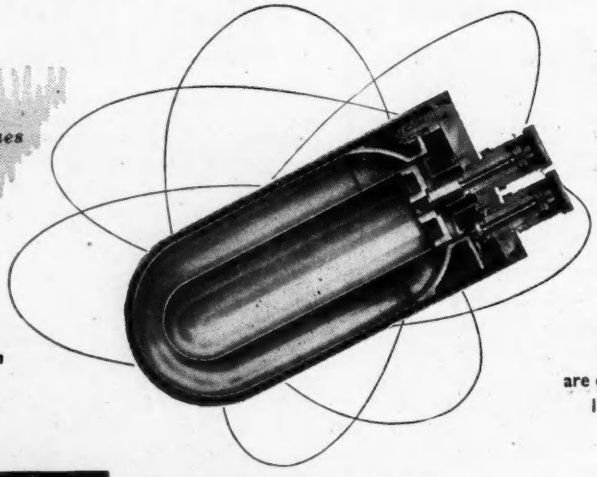

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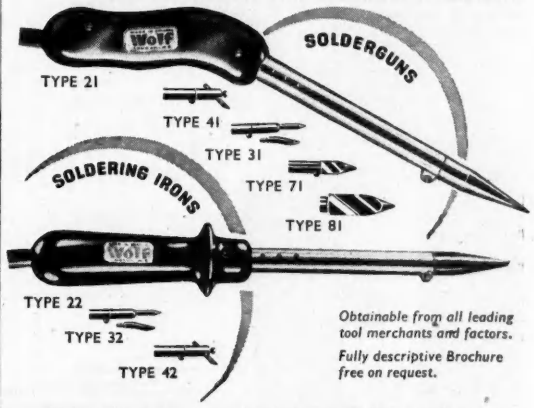

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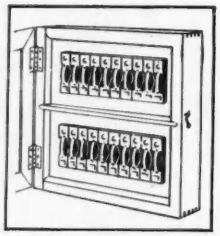

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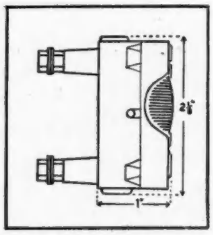

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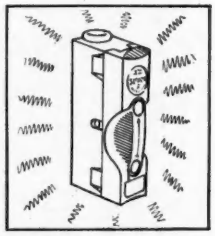

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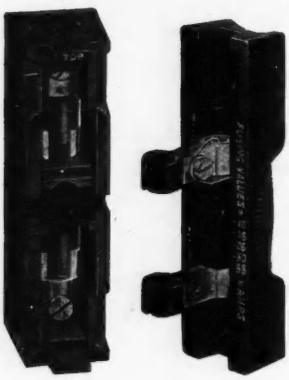

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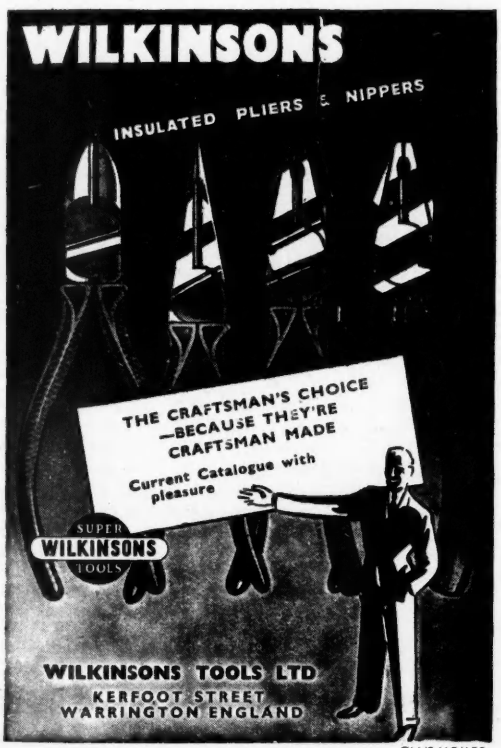

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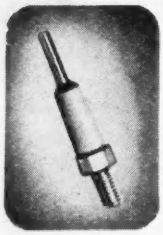

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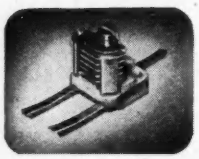

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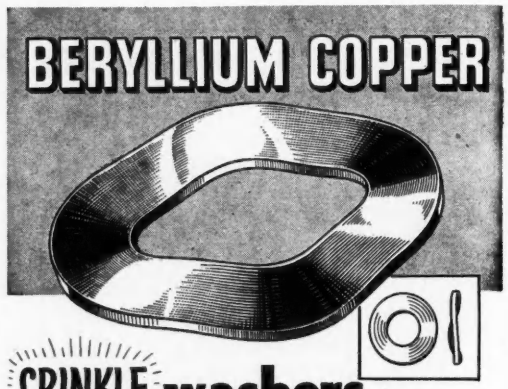

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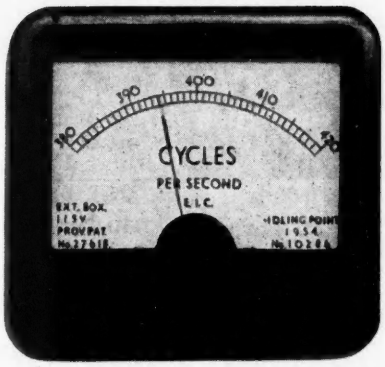

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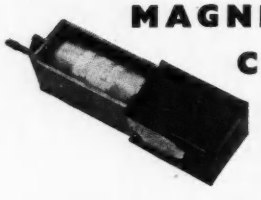

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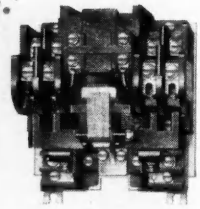

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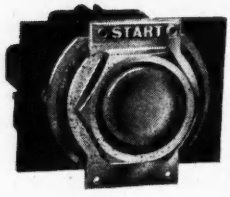

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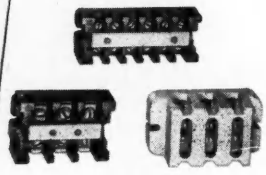

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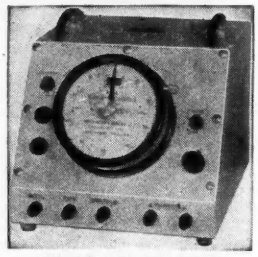

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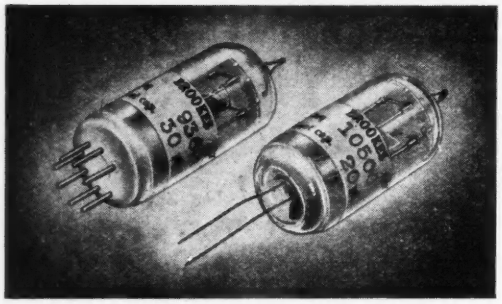

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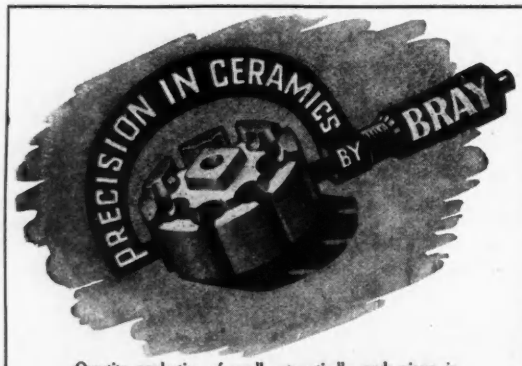

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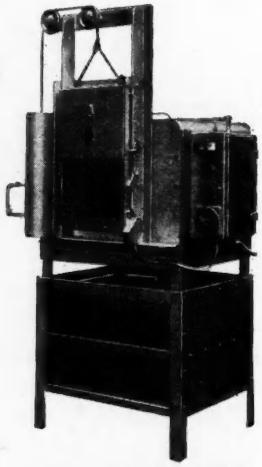

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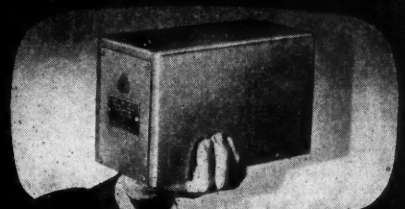

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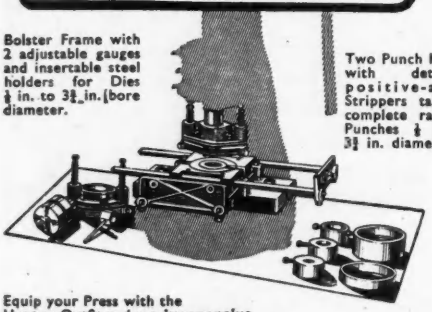

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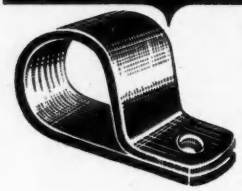

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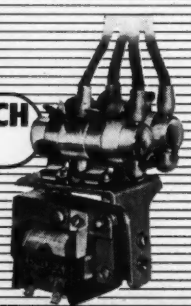

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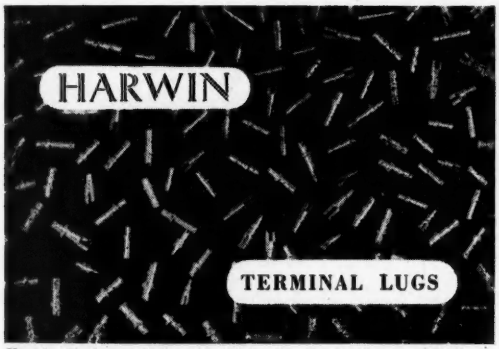

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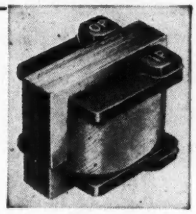

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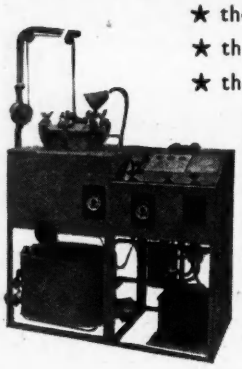

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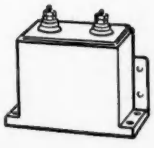
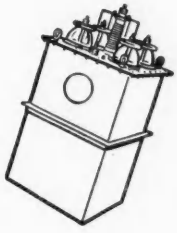
S P

SEPT

Leadership on Show

The Annual Radio Show has once again demonstrated the proud position occupied by T.C.C. Condensers — they were in the majority of chassis exhibited, as they have been at so many previous Shows. This leadership is not easily achieved nor easily held: only by constant research and development can we maintain our jealously-guarded reputation for quality. We were glad to welcome so many of our friends at our Stand, where they were able to see some of our latest productions.





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meets every requirement of

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Ersin Flux not only prevents oxidation during soldering but actually cleans surface oxides. 6 alloys and 9 gauges supplied in nominal 7-lb. reels: other alloys and gauges to special order.

Ersin Multicore Solder is made to comply with A.I.D., G.P.O., A.R.B., D.T.D. 599, R.C.S. 1000 and all U.S.A. Federal specifications. The consistently high quality of Ersin Multicore Solder as supplied to manufacturers during the past 15 years, has justified its reputation as "The Finest Cored Solder in the World".

RADIO AND T/V SERVICE ENGINEERS' 1-lb. REELS

An economy pack containing approximately 167 feet of 18 s.w.g. 50/50 alloy. Cat. Ref. R.5018 15/- each (subject).

HANDY SIZE 1 CARTONS 5/- EACH (subject)

4 specifications.

Cat. Ref. No.	Alloy Tin/Lead	S.W.G.	Approx. length per carton
C 16014	60/40	14	21 feet
*C 16018	60/40	18	55 feet
C 14013	40/60	13	19 feet
C 14016	40/60	16	38 feet

* *Specially recommended for television.*

Also available in 6d. cartons containing approx. 3 feet 40/60 Alloy 18 s.w.g.

Special MULTICORE products for specific uses

MULTICORE TAPE SOLDER

A real tin/lead solder containing cores of Ersin Flux. Melts with a match. Available to manufacturers in 3½ lb. reels.

Bib WIRE STRIPPER and CUTTER

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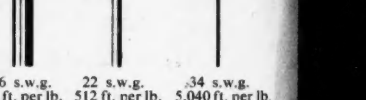


16 s.w.g. 98 ft. per lb. — 22 s.w.g. 512 ft. per lb. — 34 s.w.g. 5,040 ft. per lb.

Yes, the 34 s.w.g. does contain 3 cores of flux!

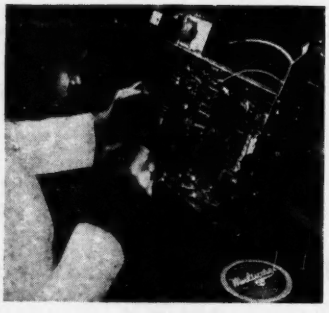
Ersin Multicore Solder can be supplied in 1 lb. reels to Manufacturers in as fine a gauge as 22 s.w.g., and on ½-lb. reels in even gauges between 24 and 34 s.w.g.

SPECIAL HIGH AND LOW MELTING POINT ALLOYS

Type	Melting point
T.L.C.	145°C
L.M.P. ALLOY (with 2% silver content)	179°C
P.T.	232°C
COMSOL (Tin/Lead/Silver)	296°C

MULTICORE STAGE ANOTHER RADIO SHOW ATTRACTION

***Ferguson operatives will solder 25,000 joints in 10 days using* ERSIN MULTICORE SOLDER**



Multicore are, once gain, the only solder manufacturers to exhibit at the Radio Show. Spectators will see personnel from Ferguson's Enfield factory assembling and soldering tuner units to be fitted to Ferguson T/V sets.

Ferguson Radio, like other leading manufacturers of electrical equipment, use Ersin Multicore Solder.

Manufacturers, who have been using Multicore Solder for 15 years, know that they can rely on its guaranteed characteristics—they know that, with the correct soldering technique, the continuous flux stream prevents dry or H.R. joints.

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